ITHACO

INSTRUCTION AND MAINTENANCE MANUAL

ITHACO 450 SERIES

DATA ACQUISITION AMPLIFIERS

DECEMBER, 1978

ITHACO INC.
735 West Clinton Street
Ithaca, New York 14850
Telephone 607-272-7640

MODIFICATION INSTRUCTIONS

ITHACO MODEL 454M125 AMPLIFIER

The Model 454M125 Amplifier differs from a standard Model 454 in that the following Options have been added:

Option 04	The addition of a meter calibrated in terms of RMS volts for a sine wave and an average detector measuring the amplifier's output.
Option 09	The addition of a 5 pin XLR connector through which preamp power +15V and amplifier input are routed.
Option 05	To change the low frequency cutoff to 20 kHz.
Option 06	To change the high frequency cutoff to 20 kHz.

ADDITIONAL DRAWINGS

Modification Instructions - Model 454M125	A12718
Modification Instructions - Option 04	A11170
Modification Instructions - Option 09	A12082

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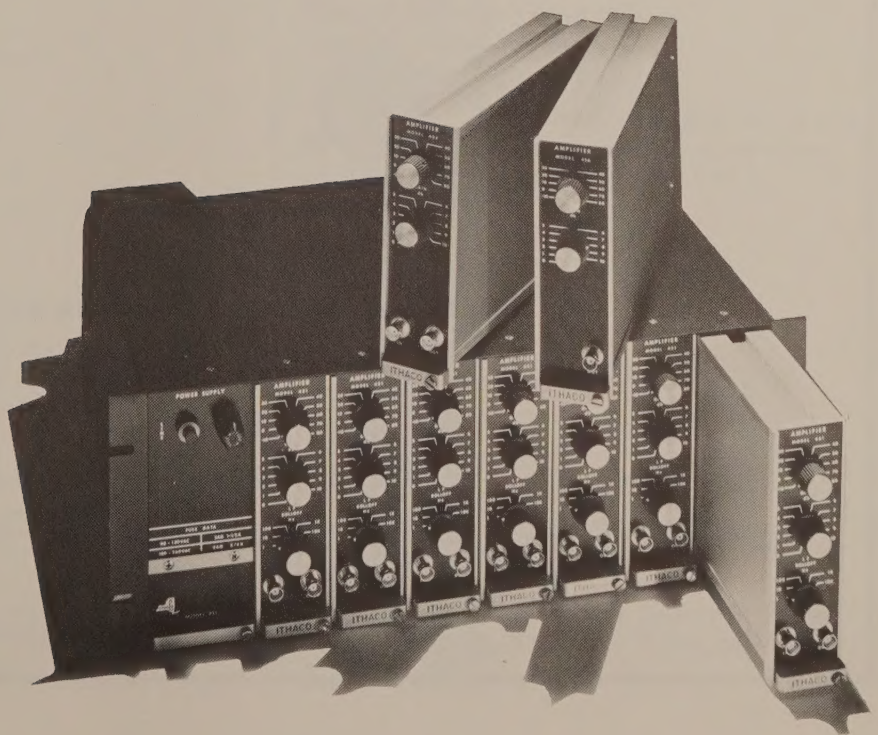
ITHACO
ac instrumentation amplifiers 450 series



IPS 109

450 SERIES INSTRUMENTATION AMPLIFIERS

- For general purpose use in acquisition and conditioning of dynamic (AC) signals
- 1 Hz to 100 kHz bandwidth
- 1% gain accuracy
- 2° phase accuracy
- 100 dB gain range in 1dB steps
- Low noise, low distortion
- No gain switching transients – fast overload recovery

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RELATED ITHACO PUBLICATIONS

IPS 104	*"Variable Electronic Filters"*
IPS 112	*"Low Noise Preamplifiers"*
IPS 115	*"AUTO–GAIN® Amplifiers*
IAN 102	*"Measuring Noise Spectra with Variable Electronic Filters"*

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE. COPIES OF ITHACO'S 12 MONTH WARRANTY ARE AVAILABLE UPON REQUEST.

PHASE AND FREQUENCY RESPONSE

Figure 1 shows the phase and frequency response of all 450 Series Models. Great care has been taken to maintain precise amplitude and phase tracking (2% and 2° respectively) between like amplifiers. This relationship is maintained through and below the –3 dB point in models with adjustable LF rolloff controls operating on the same rolloff setting. The solid curves show broadband performance of all models, and the dashed curves show response of the various LF rolloff positions of Models 451, 453, and 455.

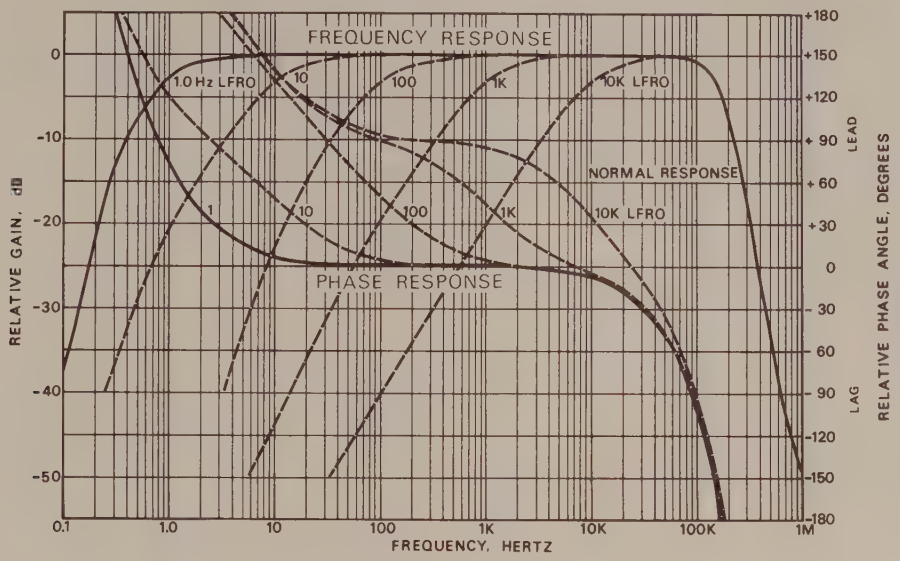
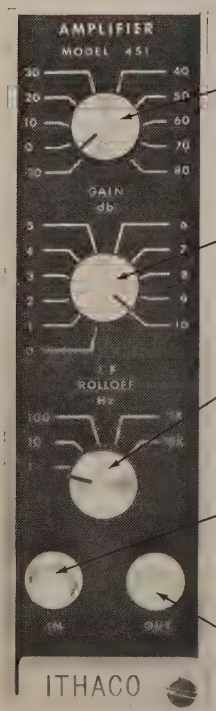


Figure 1 Phase and Frequency Response of 450 Series Amplifiers

FRONT PANEL



10 dB Gain Switch

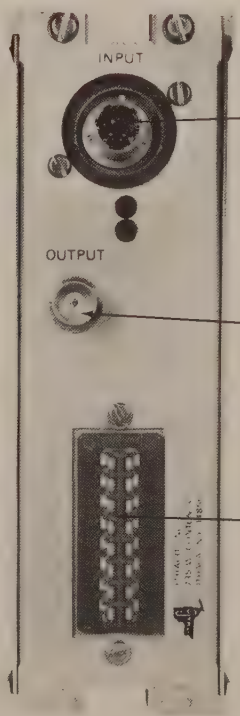
1 dB Gain Switch

Low Frequency Rolloff Switch (odd numbered models only)

Input BNC Connector (single ended models only)

Output BNC Connector

REAR PANEL



Input (Differential Models only) All other models have standard BNC's

Output

Power Input and Control Connector (Requires ±15V DC)

SPECIFICATIONS – ALL MODELS

COMMON SPECIFICATIONS	
TRANSFER CHARACTERISTICS	
GAIN RANGE	–10 dB to +90 dB in 1 dB steps
GAIN ACCURACY	±1% plus loading effect of 20Ω output impedance
GAIN STABILITY	±1% with time and temperature
HIGH FREQUENCY CUTOFF	–3 dB maximum @100 kHz
PHASE RESPONSE	Inverting (180° midband, see Figure 1)
PHASE ACCURACY	±2° maximum between channels with same rolloff setting (10 Hz to 30 kHz)
HARMONIC DISTORTION	0.5% maximum with 1.0V rms into 600Ω in passband
OUTPUT	
IMPEDANCE	20Ω maximum (DC coupled with 10mV maximum DC offset)
MAXIMUM OUTPUT	7V pk and 15 mA pk
NOISE	See page 10
ENVIRONMENT	–20°C to +55°C Operating; –55°C to +85°C Storage; R.H. 95%
POWER	±15V @35 mA Models 455 and 456 –55V @12 mA see page 8
DIMENSIONS AND WEIGHT	6.75" high x 2" wide x 10.5" deep 3 lbs.

OTHER SPECIFICATIONS

MODEL	INPUT IMPEDANCE	BROADBAND NOISE * SHORTED INPUT	COMMON MODE REJECTION	LOW FREQUENCY CUTOFF 6 dB OCTAVE SLOPE	MAXIMUM INPUT
451	1 meg, 100 pf	–110 dB (3μV)	Not Applicable	–3 dB selectable at 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz	±7V pk
452	500 meg, 100 pf	–108 dB (4μV)	Not Applicable	–3 dB @1 Hz	±7V pk
453	500 meg, 100 pf	–108 dB (4μV)	Not Applicable	–3 dB selectable at 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz	±7V pk
454	1 meg, 100 pf	–110 dB (3μV)	Not Applicable	–3 dB @1 Hz	±7V pk
455	20 meg, 10 pf (100 meg CM)	–104 dB (6.3μV)	100 dB from 60–400 Hz 60 dB anywhere in passband 5V pk max CM input	–3 dB selectable at 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz	±5V pk
456	20 meg, 10 pf (100 meg CM)	–104 dB (6.3μV)	100 dB from 60–400 Hz 60 dB anywhere in passband 5V pk max CM input	–3 dB @1 Hz	±5V pk

* see page 10

OPTIONS

OPTION	DESIGNATION	DESCRIPTION	MOUNTING CASE OPTION
01	Vernier Gain Control	1 dB step control replaced with 10 dB gain vernier	——
03	Remote Preamp +28 Volt Power	5 pin XLR connector added to rear panel to supply +28 volt power and signal connections to remote preamplifier. Models 451 and 454 only.	——
04	Meter	Front panel meter added. 1½'' dial, 3% accuracy, 2 volt rms full scale, average reading. Models 452, 454, 456 or by deleting 1 dB switch on 451, 453, 455.	——
05	Low Frequency Cutoff	6 dB/octave low frequency cutoff changed to customer specified value between 1 Hz and 10 kHz. Models 452, 454, 456 only.	——
06	High Frequency Cutoff	12 dB/octave high frequency cutoff changes to customer specified value between 20 kHz and 100 kHz. (Output Filter)	——
09	Remote Preamp ±15 Volt Power	5 pin XLR connector added to rear panel to supply ±15 volt power and signal connections for remote preamp. Models 451 and 454 only.	——
10 *	Remote Preamp Calibration System	Adds calibration system for use with specific remote preamps (see page 6 for cal system and page 9 for preamps). Models 451 and 454 only.	——
16	Connector Modification	Changes any existing connector to different connector type.	——
18	Selectable High and Low Frequency Cutoff	5 selectable 6 dB/octave frequency cutoffs added with customer specified frequencies between 500 Hz and 100 kHz	——
19	Remote Control 10 dB Gain Step	''Remote'' position added to front panel 10 dB step control. (See description, page 7)	Option 19
20	Gain Status Readout 10 dB Control	4 wires added to rear connector for 4 bit gain code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
21	Gain Status Readout 1 dB Control	4 wires added to rear connector for 4 bit gain status code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
22	Frequency Cutoff Status Readout	3 wires added to rear connector for 3 bit frequency status code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
23	Status Readout All Controls (see Options 20, 21, 22)	11 wires added to rear connector for status code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
24	Twinaxial BNC	Twinaxial BNC for differential input. Model 455 and 456 only.	——
25	5 dB Manual Gain Control	5 dB manual gain control (20 position) and a 10 dB gain vernier in 1 dB steps from –5 dB to +5 dB	——
26	5 dB Manual/Remote Gain Control	5 dB manual/remote gain control (20 position) and a 10 dB gain vernier in 1 dB steps from –5 to +5 dB (see page 7)	Option 19

*Cal Option 10 not available in combination with Option 09 because of pin limitations on preamp connector

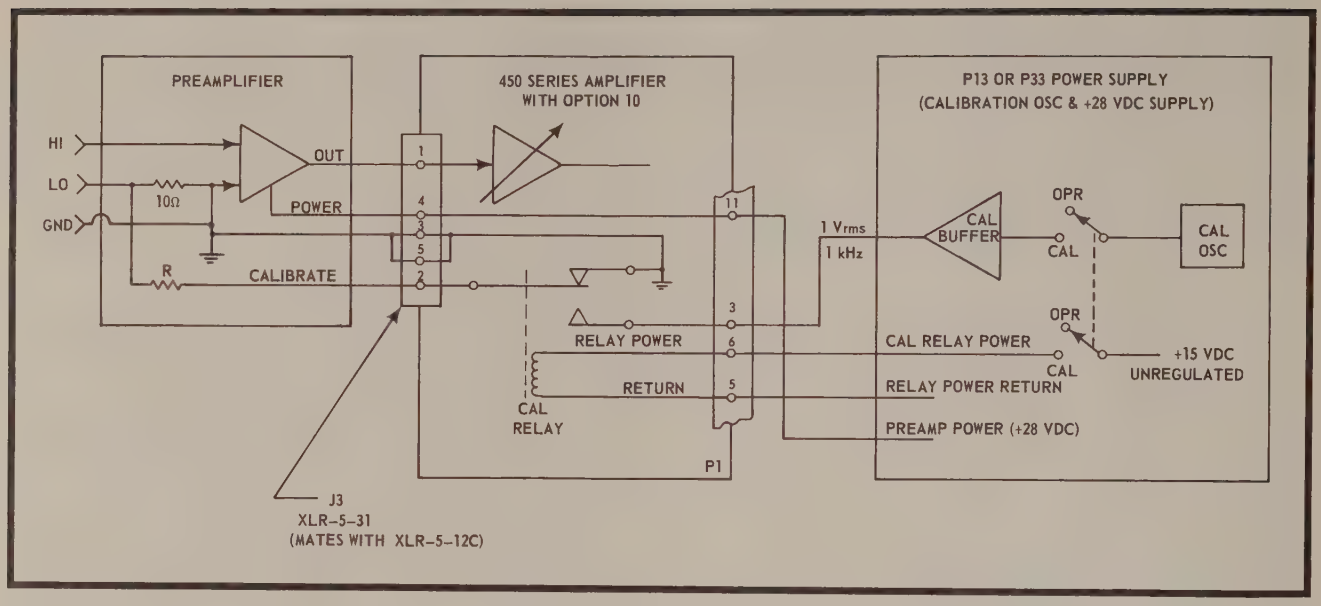


Figure 2 450 Series Calibration System – Option 10

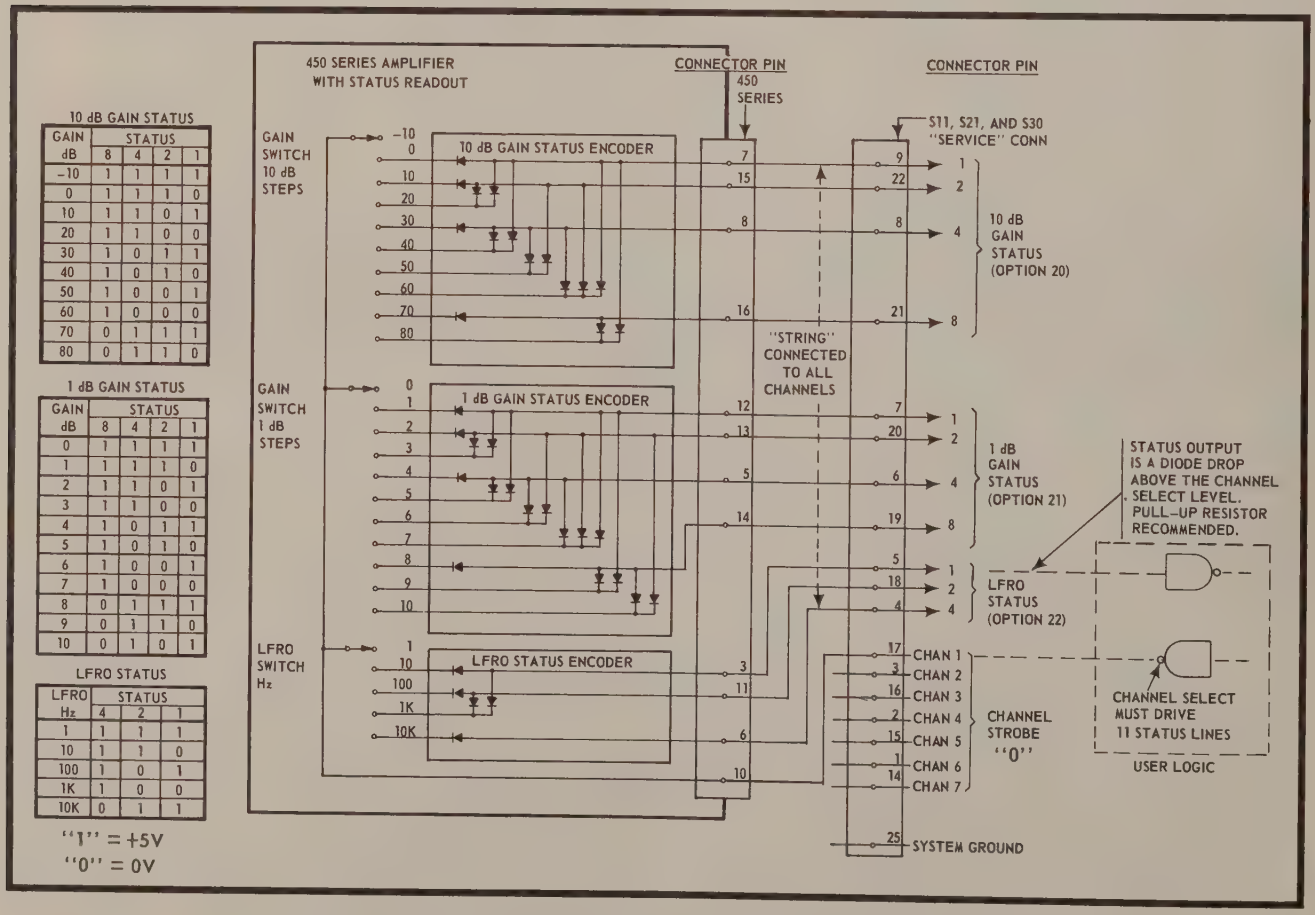
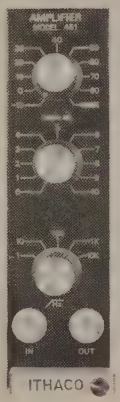

10 dB GAIN STATUS
GAIN dB | STATUS 8 4 2 1
-10 1 1 1 1
0 1 1 1 0
10 1 1 0 1
20 1 1 0 0
30 1 0 1 1
40 1 0 1 0
50 1 0 0 1
60 1 0 0 0
70 0 1 1 1
80 0 1 1 0
1 dB GAIN STATUS
GAIN dB | STATUS 8 4 2 1
0 1 1 1 1
1 1 1 1 0
2 1 1 0 1
3 1 1 0 0
4 1 0 1 1
5 1 0 1 0
6 1 0 0 1
7 1 0 0 0
8 0 1 1 1
9 0 1 1 0
10 0 1 0 1
LFRO STATUS
LFRO Hz | STATUS 4 2 1
1 1 1 1
10 1 1 0
100 1 0 1
1K 1 0 0
10K 0 1 1
"1" = +5V
"0" = 0V
450 SERIES AMPLIFIER WITH STATUS READOUT
CONNECTOR PIN 450 SERIES
CONNECTOR PIN
S11, S21, AND S30 "SERVICE" CONN
GAIN SWITCH 10 dB STEPS
10 dB GAIN STATUS ENCODER
10 dB GAIN STATUS (OPTION 20)
"STRING" CONNECTED TO ALL CHANNELS
GAIN SWITCH 1 dB STEPS
1 dB GAIN STATUS ENCODER
1 dB GAIN STATUS (OPTION 21)
LFRO SWITCH Hz
LFRO STATUS ENCODER
LFRO STATUS (OPTION 22)
STATUS OUTPUT IS A DIODE DROP ABOVE THE CHANNEL SELECT LEVEL. PULL-UP RESISTOR RECOMMENDED.
CHAN 1
CHAN 2
CHAN 3
CHAN 4
CHAN 5
CHAN 6
CHAN 7
CHANNEL STROBE "0"
CHANNEL SELECT MUST DRIVE 11 STATUS LINES
USER LOGIC
SYSTEM GROUND

Figure 3 . 450 Series Status Readout – Options 20, 21, 22, and 23

REMOTE GAIN CONTROL OPTIONS

(Simultaneous Gain Control of up to 34 Amplifiers)



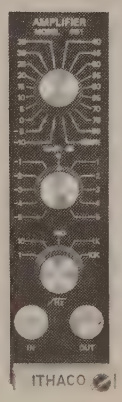
451 (Option 19)

450C1

10 dB REMOTE GAIN CONTROL

450 SERIES AMPLIFIERS WITH OPTION 19
(Manual/Remote Control of 10 dB gain steps)

450C1 Remote Gain Control Unit
S11, S21, or S30 Cases all require Option 19
P Series Power Supplies
450V2 Cable (one required for each additional case)



451 (Option 26)

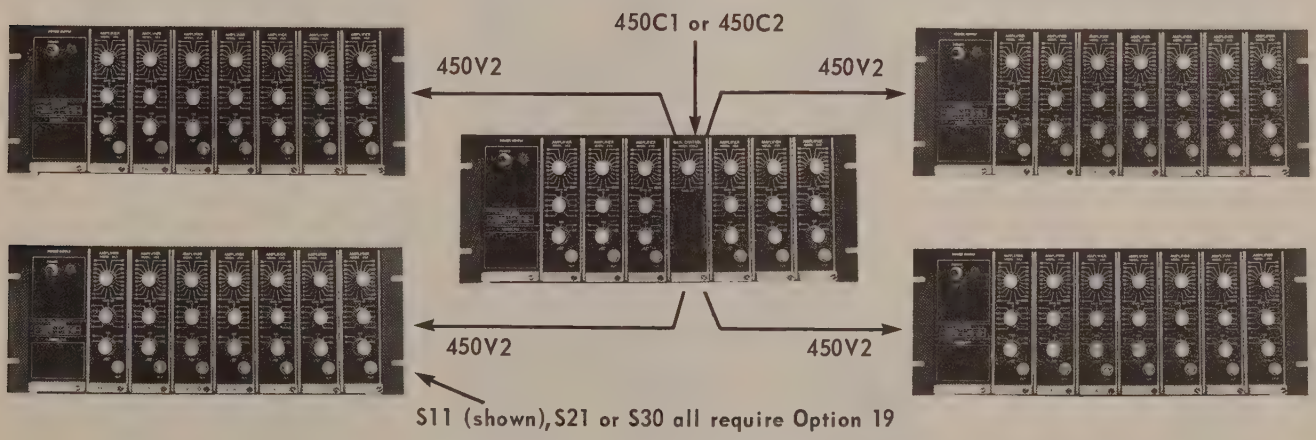
450C2

5 dB REMOTE GAIN CONTROL

450 SERIES AMPLIFIERS WITH OPTION 26
(Manual/Remote Control of 5 dB gain steps)

450C2 Remote Gain Control Unit
S11, S21, or S30 Cases all require Option 19
P Series Power Supplies
450V2 Cable (one required for each additional case)

NOTE: Maximum output reduced for gain vernier setting between –2 dB and –5 dB. (Maximum output at least 4V rms)



REMOTE GAIN CONTROL SYSTEM

A Remote Gain Control System can be formed by plugging a remote control unit in a case with Option 19 along with 450 Series Amplifiers with a remote gain control option. Up to four additional cases of amplifiers can be controlled by a remote gain control unit via 450V2 Convenience Cables. In systems employing more than one power supply, the control unit will continue to operate as long as one of the cases contains an operating power supply.

Figure 4 Remote Gain Control Options – Options 19 and 26

ACCESSORIES

CABLES, CONNECTORS, AND OTHER ACCESSORIES

450V1M7	7 FT. PREAMP CABLE (Connects amplifier with preamplifier)
450V2	CONVENIENCE CABLE (Connects 450C1 or 450C2 with mounting cases)
X1	6 FOOT EXTENDER CABLE (Blank Plug–In with extender cable)
Y1	BLANK FRONT PANEL
Z1	EMPTY AMPLIFIER CHASSIS

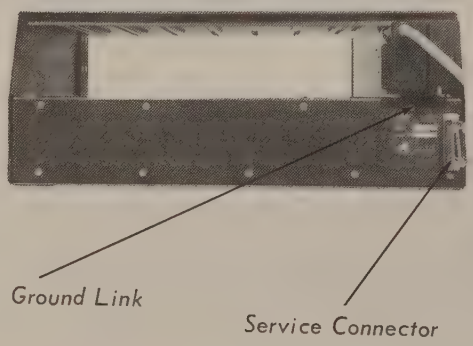
MATING CONNECTORS

Use With	Description	Manufacturer Part Number	ITHACO Part Number
S11, S21, S30 Cases	Service Connector on rear panel	Cannon DBM–25P	A11234G1
Models 455, 456	Differential input connector	KPT06B8–4S	812104004
Options 03, 09, 10	5 pin XLR connector	Cannon XLR–5–12C	812123005
Option 24	Twinaxial BNC	Amphenol 31–224	812130108

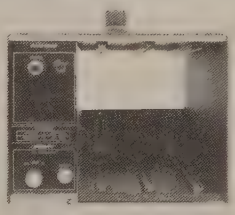
MOUNTING CASES

MODEL S11
7 CHANNEL MOUNTING CASE

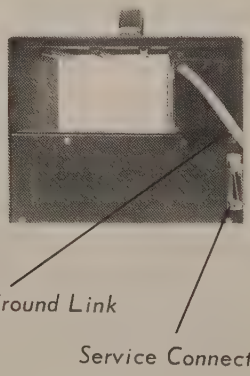
DIMENSIONS: 7" high x 19" wide x 14" deep
WEIGHT: 25 lbs. including power supply



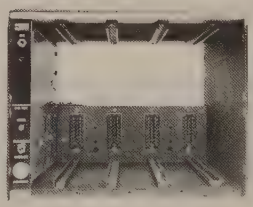
MODEL S21
3 CHANNEL PORTABLE CASE



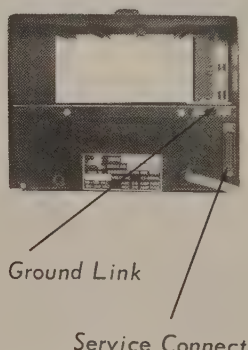
DIMENSIONS: 7.2" high x 9.1" wide x 12.3" deep
WEIGHT: 15 lbs. including power supply



MODEL S30
4 CHANNEL PORTABLE CASE



DIMENSIONS: 7.2" high x 9.1" wide x 14.2" deep
WEIGHT: 12 lbs. including power supply



ACCESSORIES (Continued)

POWER SUPPLIES

MODEL	P11	P12	P13	P14	P33	P34	P37
VOLTAGE	±15V	±15V, +28V	±15V, +28V	±15V, −55V	±15V, +28V	±15V, −55V	±15V
CURRENT	1A	1A (±15V) 200mA (+28V)	1A (±15V) 200mA (±28V)	1A (±15V) 0.1A (−55V)	500mA (±15V) 100mA (+28V)	1A (±15V) 0.05A (−55V)	500mA
LINE REGULATION	.05%	.05%	.05%	.05%	.05%	.05%	.05%
LOAD REGULATION	.01%	.01%	.01%	.01%	.01%	.01%	.01%
STABILITY	±.1%/day	±.1%/day	±.1%/day	±.1%/day	±.1%/day	±.1%/day	±.1%/day
RIPPLE AND NOISE	45μV rms	45μV rms	45μV rms	45μV rms	45μV rms	45μV rms	45μV rms
CAL OSCILLATOR	No	No	Yes	No	Yes	Yes	Yes
MOUNTING CASE	S11, S21	S11, S21	S11, S21	S11, S21	S30	S30	S30
LINE FREQUENCY	47–440 Hz	47–440 Hz	47–440 Hz	47–440 Hz	47–440 Hz	47–440 Hz	47–440 Hz
WEIGHT	9 lbs.	9 lbs.	9 lbs.	9 lbs.	1 lb.	1 lb.	1 lb.
SIZE	6.75" h x 2.75" w x 12.25" d				6.75" h x .72" w x 10" d		
USE WITH	451, 452, 453, 454, Most Options	451, 454, w/Opt 03	451, 454, w/Opt 01	Required w/ 455, 456	451, 452, 453, 454, Opt 03, 10	Required w/ 455, 456	451, 452, 453, 454, Most Options

POWER SUPPLY FEATURES

- POWER SUPPLY REGULATION ±15V .05% line, .01% load
- SHORT CIRCUIT PROTECTED
- LINE FREQUENCY 47 – 440 Hz
- BATTERY POWER INPUT ON REAR CONNECTOR

POWER SUPPLY OPTIONS

- STANDARD 105V – 130V
- OPTION 01 90V – 110V
- OPTION 02 180V – 220V
- OPTION 03 210V – 260V

PREAMPLIFIERS

SPECIFICATIONS

MODEL	143L	144L
INPUT	Single–Ended	Single–Ended
INPUT Z	1000M // 15pF	1000M // 15pF
BANDWIDTH	.5 Hz – 200 kHz	.5 Hz – 200 kHz
GAIN	10 (20dB)	100 (40dB)
OUTPUT VOLTS	±8V	±8V
POWER SUPPLY VOLTAGE	+28V	+28V
NOISE	See page 10	

Model 144L

* For other applicable preamplifiers, see ITHACO Bulletin IPS 112 "Low Noise Preamplifiers"

SPECIFICATIONS

	451, 454	452, 453	455, 456
BROADBAND NOISE (maximum)	dB re 1 volt rms referred to input, measured at 25°C and at maximum gain		
Shorted Input	−110 dBV (3μV)	−108 dBV (4μV)	−104 dBV (6.3μV)
1000 pf Source	---	−106 dBV (5μV)	−104 dBV (6.3μV)
100 pf Source	---	−100 dBV (10μV)	− 99 dBV (11μV)
SPECTRAL NOISE (maximum)	(1 Hz BW in dB re 1 volt rms, measured at 25°C and at maximum gain)		
Shorted @100 Hz	−150 dBV (32nV/$\sqrt{Hz}$)	−148 dBV (40nV/$\sqrt{Hz}$)	−142 dBV (80nV/$\sqrt{Hz}$)
Input @ 10 kHz	−161 dBV (9nV/$\sqrt{Hz}$)	−159 dBV (11nV/$\sqrt{Hz}$)	−155 dBV (12nV/$\sqrt{Hz}$)
1000 pf @100 Hz	---	−145 dBV (55nV/$\sqrt{Hz}$)	−155 dBV (12nV/$\sqrt{Hz}$)
Source @ 10 kHz	−160 dBV (10nV/$\sqrt{Hz}$)	−159 dBV (11nV/$\sqrt{Hz}$)	−154 dBV (20nV/$\sqrt{Hz}$)
OUTPUT NOISE	600μV rms broadband at minimum gain, measured at 25°C		

TO COMPUTE AMPLIFIER OR PREAMPLIFIER NOISE FOR ANY SOURCE IMPEDANCE AND ANY BANDWIDTH:

In Figure 5, Z_s is the complex impedance of the source. e_n and i_n are input stage noise voltage and current respectively. Total noise E_n referred to the input is:

$E_n = \sqrt{[e_n^2 + (i_n Z_s)^2]}\ BW$, where BW is the bandwidth of interest. For broadband computations where e_n and i_n are not constant:

a) Divide bandwidth of interest into small intervals.

b) Compute noise for each such interval using the average values of e_n and i_n for that interval.

c) Make an rms summation of the noise for all intervals to find E_n (see IAN−102).

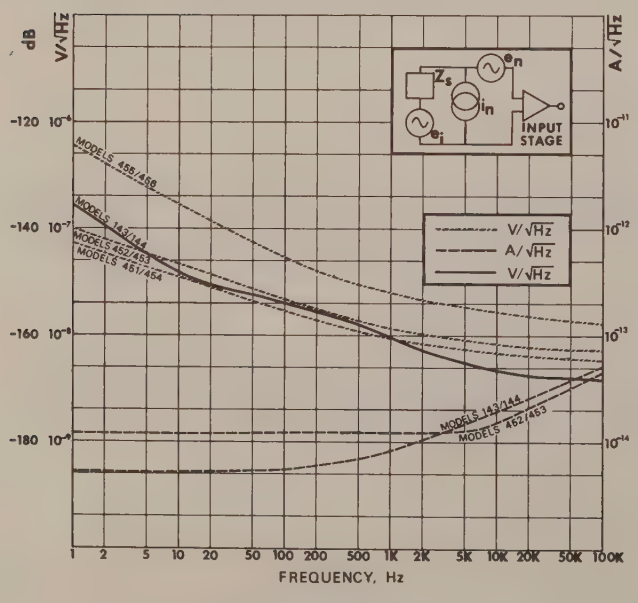


Figure 5 Spectral Noise of Amplifiers and Accessory Preamplifiers

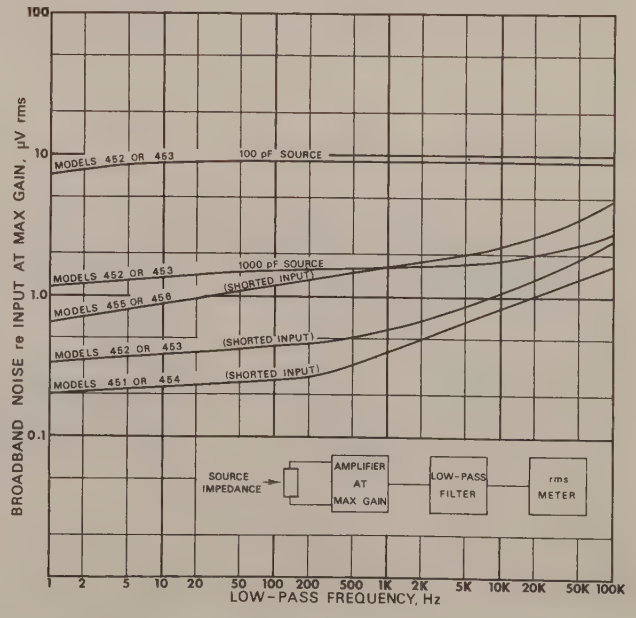


Figure 6 Broadband Noise as a Function of Bandwidth

ITHACO PRODUCTS INCLUDE:

scientific and engineering
lock–in amplifiers, light beam choppers, ratiometers, low noise preamplifiers, electronic filters

data acquisition
instrumentation amplifiers, seismic amplifiers, auto–ranging amplifiers, computer–controlled amplifiers, charge amplifiers, dynamic strain amplifiers, low noise preamplifiers, multiple channel electronic filters, anti alias filters

agricultural
ultrasonic instruments for live animal evaluation

spacecraft
horizon scanners and attitude control system components

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SECTION 2

2.0 OPERATING INSTRUCTIONS

2.1 MOUNTING AND OPERATION

2.1.1 INDEPENDENT AMPLIFIER

1. Make the following connections to a 16 pin Blue Ribbon connector which mates with Amphenol #26-4100-16P:

Pin	Connection
1	-15v ± 1%
2	Signal Ground
9	+15v ± 1%
4	-55v ± 3% (Models 455 & 456)
11	Preamp Power (Option 03)

2. Connect (1) to rear connector on amplifier. Connect Signal Source and output monitoring equipment to appropriate BNC connectors.

   CAUTION: Since the amplifier package is at signal ground, care should be taken to insulate it from chassis or power ground. Otherwise undesirable ground currents may result.

3. Set desired gain and low frequency rolloff. The low frequency rolloff approaches 6 dB/octave below the frequency set by the front panel switch marked $\sqrt{\text{Hz}}$. As long as the input signal remains below 14v p-p, the amplifier output stage will saturate before the input stages regardless of low frequency rolloff or gain setting.

4. Apply DC power and begin operation.

2.1.2 AMPLIFIER IN S11 RACKMOUNT

1. Mount the S11 Rackmount in a 19" standard RETMA relay rack.

2. Plug up to 7 channels of 450 Series Amplifiers into rackmount. Insert power supply channel in extreme left slot only.

3. Connect power supply power cord to 117v, 60 Hz line, and turn power supply on.

4. Connect signal sources and output monitoring equipment to appropriate BNC connectors.

5. Set desired gain and low frequency rolloff, and begin operation.

2.1.3 AMPLIFIER IN S21 PORTABLE CASE

1. Plug up to three channels of 450 Series Amplifiers into portable case leaving the extreme left slot vacant. Plug power supply in extreme left slot.

2. Connect power supply power cord to 117v, 60 Hz line, and turn power supply on.

3. Connect signal sources and output monitoring equipment to appropriate BNC connectors.

4. Set desired gain and low frequency rolloff, and begin operation.

2.1.4 POWER SUPPLIES

1. Models 451, 452, 453 and 454 use Model P11 supply.

2. Models 455 and 456 use Model P14 supply.

3. Option 03
   Use Model P12 for positive preamp power.
   Use Model P15 for negative preamp power.

2.1.5 EXTERNAL PREAMP POWER (OPTION 03)

Rear panel input BNC replaced by 5 pin XLR connector (J3).

J3-1	INPUT
J3-3	Ground
J3-4	Preamp Power

2.1.6 DIFFERENTIAL INPUT CONNECTOR - Models 455 and 456

Rear panel input BNC replaced by KPT Differential Input Connector.

A	Inverting Input
B	Common Mode
C	Non-Inverting Input
D	Common Mode

3.0 THEORY OF OPERATION

3.1 INTRODUCTION

The internal organization of the 450 Series Amplifiers is shown in Figure 3.1. Basically, the amplifier consists of a unity gain input stage, 0/10/20/30 dB attenuator, 20 dB gain stage, 0/10/20/30 dB attenuator, 30 dB gain stage, 0/10/20/30 dB attenuator, 30 dB gain stage, 1 dB step attenuator, and 10 dB gain stage. Each of 0/10/20/30 dB attenuators is electronically switched from the front panel 10 dB/step gain switch. The 10 dB attenuator is mechanically switched by the front panel 1 dB/step gain switch. The third front panel control, the Low Frequency Rolloff switch, electronically switches four of the five rolloff capacitors, the remaining capacitor being the input coupling capacitor.

The 450 Series Amplifiers contain input and output BNC's on both the front and rear panels. The input BNC's are tied in parallel, as are the output BNC's.

Since the 450 Series makes extensive use of modular, solid-state circuitry, the following discussion will be on a module basis.

3.2 INPUT STAGE AND ATTENUATOR (A-1)

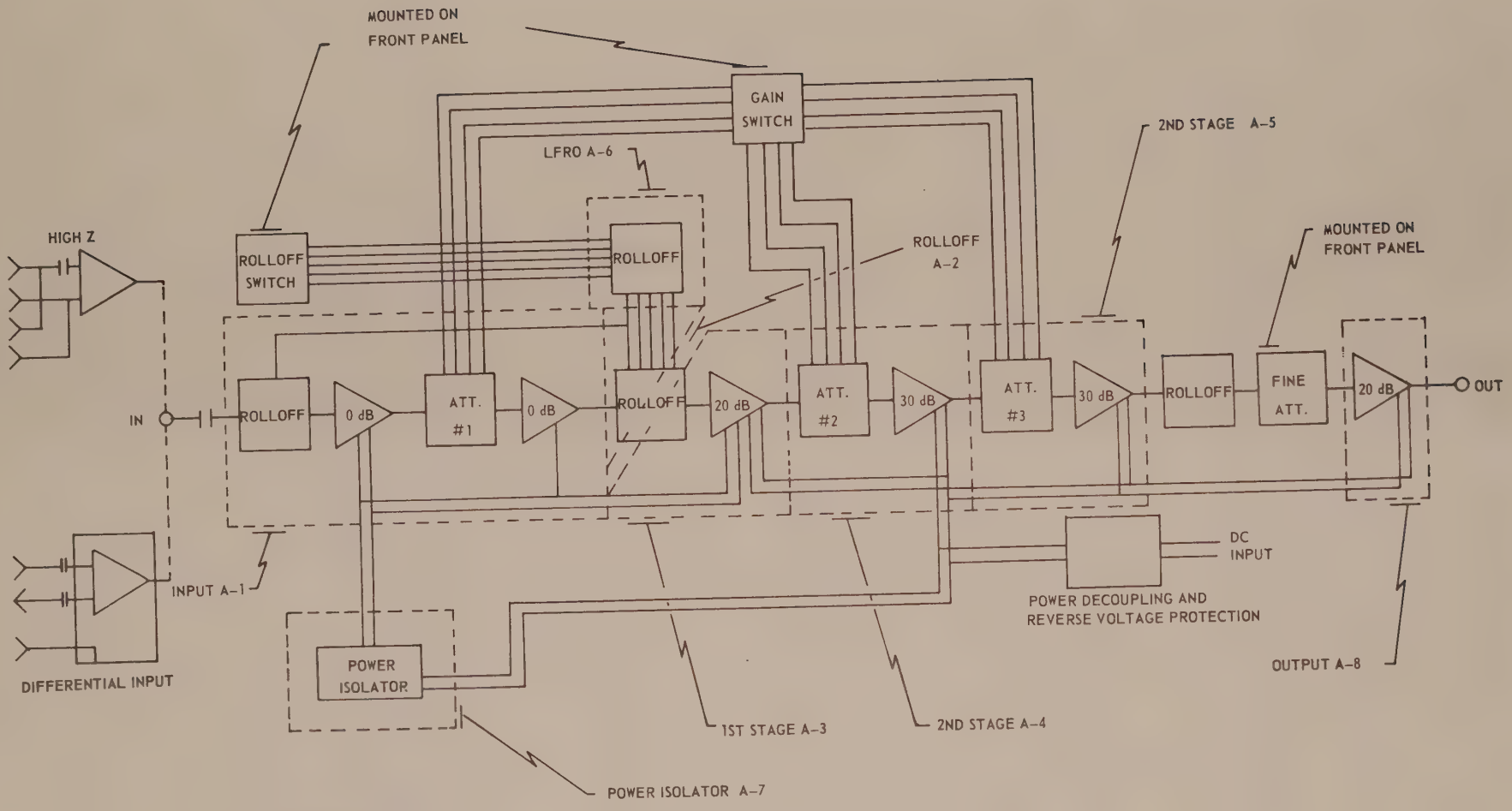
As is evident from Figure 3.1, the incoming signal is coupled into the input unity gain stage by the 1 Hz and 10 Hz rolloff capacitors. The former is always present in all models, the latter being present only when the 10 Hz rolloff position (451, 453 and 455 only) is activated from the front panel. The unity gain input stage is a high input impedance, low noise FET stage. This stage drives attenuator #1 which is electronically switched and provides 0 dB attenuation for all amplifier gain settings above 20 dB. The second unity gain stage is a complimentary pair which drives the 100, 1K, and 10 KHz rolloff coupling capacitors (451, 453 and 455 only).

3.3 FIRST STAGE AMPLIFIER (A-3)

The First Stage Amplifier contains the 100 Hz rolloff capacitors, (451, 453 and 455 only), and a fixed 20 dB gain amplifier. The amplifier is an inverting operational amplifier, fed back for 20 dB gain.

3.4 SECOND STAGE AMPLIFIER AND ATTENUATOR I AND II (A-4, A-5)

Following the First Stage Amplifier is a second 30 dB electronically switched 0/10/20/30 dB attenuator and a 30 dB operational amplifier. The attenuator provides 0 dB attenuation for overall gains above 50 dB, and 30 dB attenuation for overall gains below 20 dB. The 30 dB oper-



450 SERIES FUNCTIONAL BLOCK DIAGRAM

FIGURE 3.1

ational amplifier has a FET input and a complimentary output stage which is not current limited. Thus, care should be taken to avoid shorting the output during maintenance.

The above module is repeated as the Second Stage Amplifier and Attenuator II. The output of this stage drives an R, L, C low pass filter, tuned and damped to provide less than 3 dB of rolloff at 100 KHz.

Following the high frequency rolloff is the 10 dB, fine attenuator physically located on the front panel which provides 10 dB of attenuation in 1 dB steps.

3.5 OUTPUT STAGE (A-8)

The final amplification stage consists of a 10 dB differential amplifier with a complimentary output stage. This stage also contains a current limiting feature which prevents amplifier damage, should the DC coupled output be short circuited. The gain of the output stage is adjustable to provide for overall amplifier gain trim. This adjustment consists of a potentiometer on the main board.

3.6 LOW FREQUENCY ROLLOFF SWITCH (A-6) (451, 453 and 455 only)

The Low Frequency Rolloff Switch Module contains the biasing circuitry and control points for the solid-state rolloff switches. The front panel switch merely serves to switch decoupled -15v to the appropriate control point in this module.

3.7 ROLLOFF MODULE (A-2) (451, 453, 455 only)

This module consists of the solid-state switches and rolloff capacitors for the 1 KHz and 10 KHz rolloff settings. It derives its control and bias voltages from the module discussed in 3.6.

3.8 POWER ISOLATOR (A-7)

The Power Isolator Module is a pair of grounded base stages which decouple and filter the DC power used by the Input Stage and First Stage amplifiers. This makes the first stages of amplification less sensitive to dynamic power supply noise, and provides power line isolation between the first stage amplifiers and the remainder of the amplifier.

TABLE I

AMPLIFIER SECTION

Gain (dB)	-10	0	10	20	30	40	50	60	70	80	90*
Overall											
Input v rms	3.16	1.0	.316	.1	.0316	.01	.00316	.001	.000316	.0001	.0000316
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Input Stage A1											
Input v rms	3.16	1.0	.316	.1	.0316	.01	.00316	.001	.000316	.0001	.0000316
Output rms	100 mv	100 mv	100 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv	.1 mv	.0316 mv
Pin 5 VDC	+8	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15
Pin 6 VDC	-15	+8	-15	-15	-15	-15	-15	-15	-15	-15	-15
Pin 14 VDC	-15	-15	+8	-15	-15	-15	-15	-15	-15	-15	-15
Pin 16 VDC	-15	-15	-15	+8	+8	+8	+8	+8	+8	+8	+8
First Stage (A3)											
Input rms	100 mv	100 mv	100 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv	.1 mv	.0316 mv
Output v rms	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv
Second Stage #1 (A4)											
Input v rms	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv
Pin 2 VDC	+8	+8	+8	+8	-15	-15	-15	-15	-15	-15	-15
Pin 1 VDC	-15	-15	-15	-15	+8	-15	-15	-15	-15	-15	-15
Pin 18 VDC	-15	-15	-15	-15	-15	+8	-15	-15	-15	-15	-15
Pin 19 VDC	-15	-15	-15	-15	-15	-15	+8	+8	+8	+8	+8
Second Stage #2 (A5)											
Input v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.316
Pin 2 VDC	+8	+8	+8	+8	+8	+8	+8	-15	-15	-15	-15
Pin 1 VDC	-15	-15	-15	-15	-15	-15	-15	+8	-15	-15	-15
Pin 18 VDC	-15	-15	-15	-15	-15	-15	-15	-15	+8	-15	-15
Pin 19 VDC	-15	-15	-15	-15	-15	-15	-15	-15	-15	+8	+8
Output Stage (A8)											
Input v rms	.316	.316	.316	.316	.316	.316	.316	.316	.316	.316	.316
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

*Indicates Fine Gain Switch in 10 dB position. All other measurements require the Fine Gain Switch to be in the 0 dB position.

4.0 CALIBRATION AND MAINTENANCE

4.1 INTRODUCTION

The extensive use of modular, solid-state circuitry makes calibration and maintenance of the 450 Series extremely easy. The amplifier side panels may be removed to provide access to the main card by removing the two screws at the rear of each side panel, and sliding the side panel toward the rear of the amplifier. The left side panel provides access to the component side of the main board.

4.2 CALIBRATION

4.2.1 OUTPUT OFFSET

With no signal input and the amplifier at minimum gain, adjust the left hand potentiometer, (R6), on the main board until the output offset is within 2 mv of ground.

4.2.2 OVERALL AMPLIFIER GAIN

At a frequency of 1 KHz, rolloff of 1 Hz, and 0 dB of gain, adjust the right hand potentiometer, (R7), on the main board until gain is 0 dB ± 0.1 dB.

4.2.3 HIGH FREQUENCY ROLLOFF

Set gain to 0 dB and low frequency rolloff to 1 Hz. With an input signal of 1v rms at 160.0 KHz, short R4 on the main board and adjust L1 until the amplifier output reaches its peak value. Remove the short from R4 and check output at 100 KHz level. Output should be 1.5 to 2 dB below its 1 KHz level.

CAUTION: Be sure to use nylon or plastic tool to adjust L1 in order to avoid damaging the ferrite slug or obtaining an incorrect adjustment.

4.3 MAINTENANCE

4.3.1 INTRODUCTION

The modular construction techniques used in the 450 Series permit rapid fault isolation. No attempt should be made to repair a module, but rather it should be replaced. However, unless the user has suitable equipment for removing the modules, and is familiar with solid-state circuitry, the amplifier should be returned to the factory for repair. The only tools

which are necessary to remove modules are a soldering iron attachment which applies uniform heat to all module pins simultaneously, and a tool for lifting the module off the main board. Even with these tools, care must be taken to heat only the points to be removed, to prevent destruction of the printed circuit pads and runs. After removing a module, excess solder must be removed from the holes in the main board prior to installing a new module.

In an emergency, a module may be removed as follows: desolder each module pin from a motherboard using an Edsyn Standard Module "Soldapullet" or equivalent desoldering tool. Insure that the pins are free by carefully moving them from side to side with long-nose pliers. Lift the module from the board, insert a new module, and resolder all pins. During the desoldering and soldering process care must be taken to avoid heating the pins and printed circuit runs for longer than four or five seconds at a time. If this limit is exceeded, loss of printed circuitry may result.

The following troubleshooting procedure is recommended for user convenience. In any event, maintenance should only be attempted by persons familiar with solid-state circuitry.

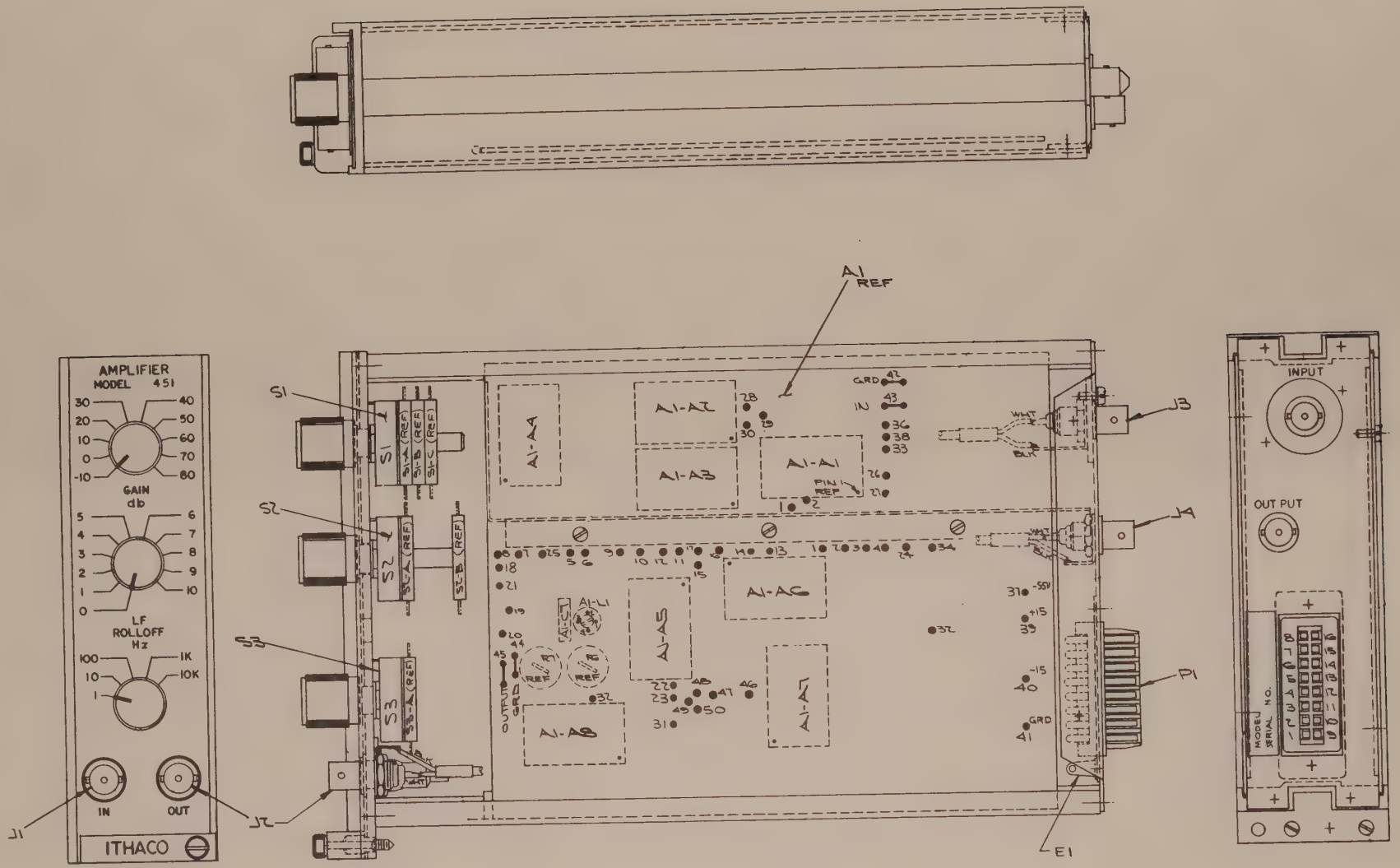
4.3.2 AMPLIFIER FAILURE

To assist in troubleshooting a failure in the amplifier or gain control circuitry, Table I and main board drawings are provided. All signal voltages in Table I are approximate except the output voltage. Thus, minor deviations do not necessarily mean a malfunction has occurred. DC voltages in Table I should be measured with a probe of 10 megohm impedance or greater. The measurements in Table I are valid for the fine gain switch set in the 0 dB position except for the 90 dB column. For this column, the fine gain switch should be set to 10 dB.

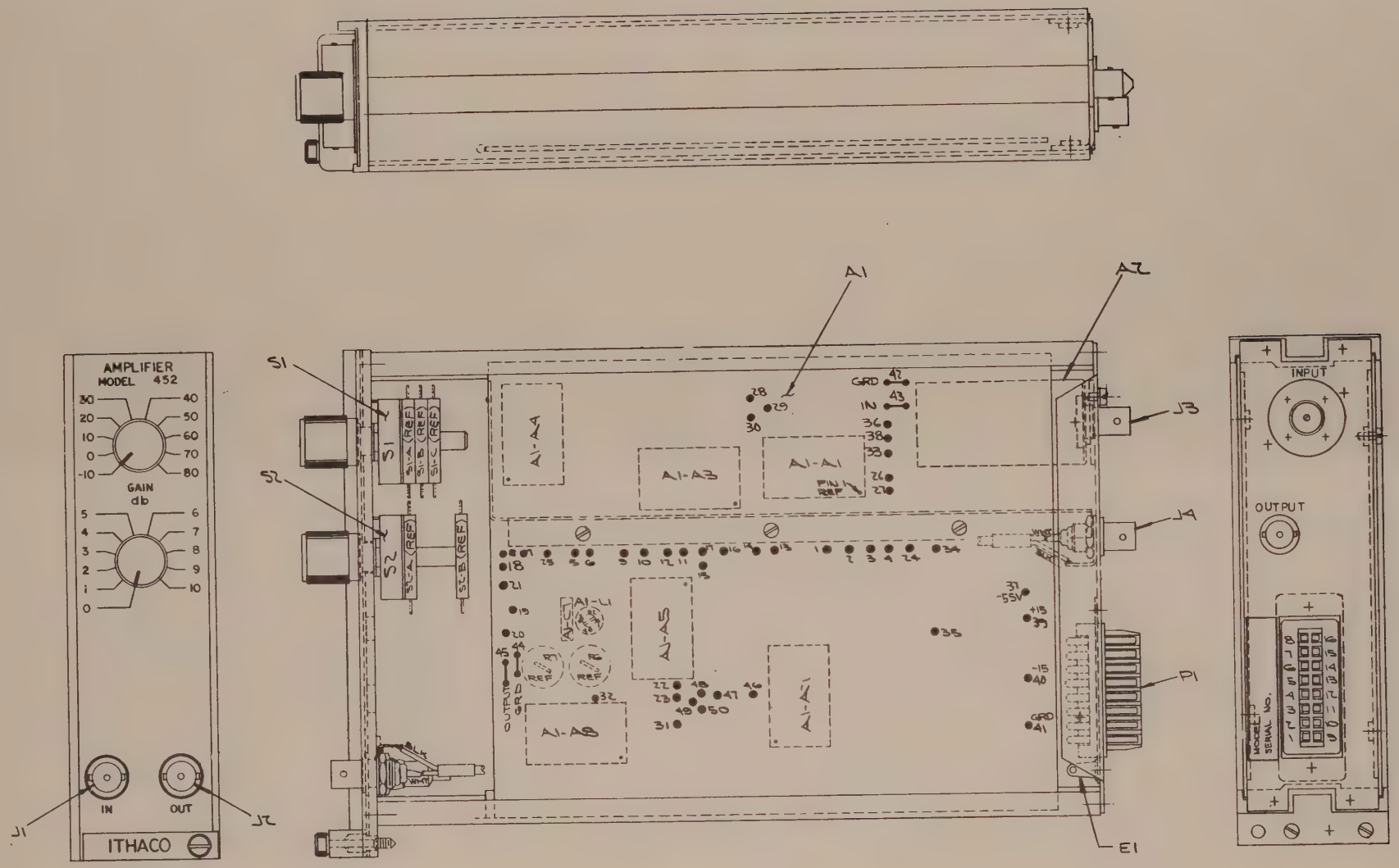
The ±15 VDC lines should read ±15 VDC ± 1%, and the decoupled ±15 VDC lines should read approximately ±13 VDC ± 1v.

Modular pin designations have a 1R designation on the main board for pin Number 1 and each pin position is counted whether or not there is a pin in that location. In addition, Pin 12 is designated 12R on the main board to further assist in counting pins. Again it must be pointed out that in determining pins, it is the location that must be counted rather than the actual pins.

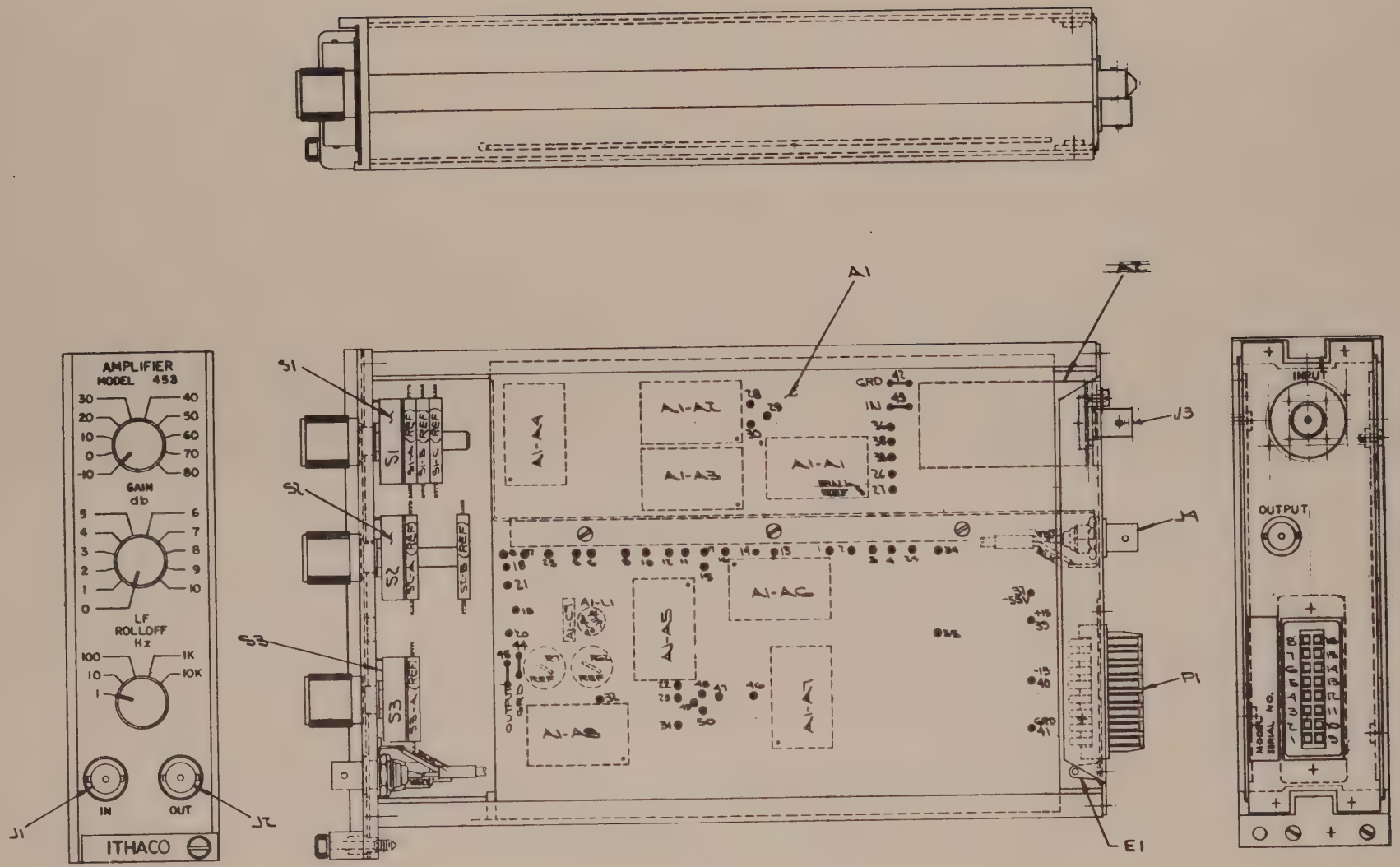
NOTE: Because of overall amp gain adjustment in output stage, AC measurements are approximate. Gain status logic uses 10 meg pull-up R, measurements should be made with 10 meg, or greater, probe. If +8 levels measure +3 or greater, signal level is o.k.



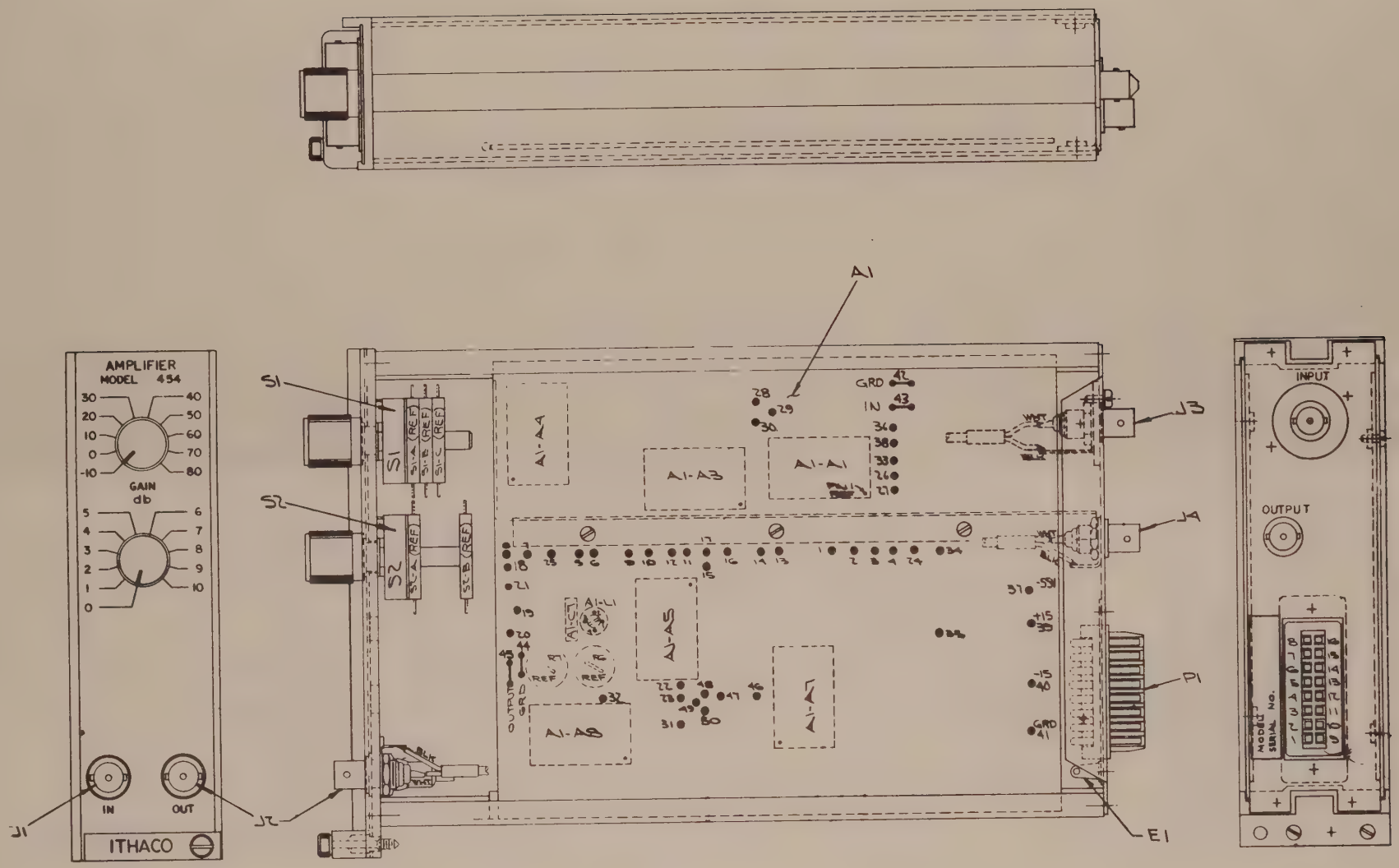
MODEL 451 AMPLIFIER
ASSEMBLY



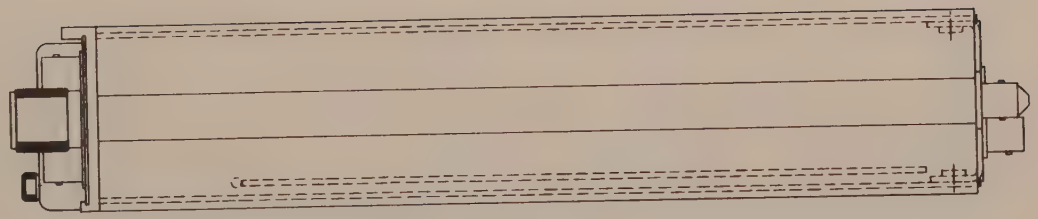
MODEL 452 AMPLIFIER
ASSEMBLY

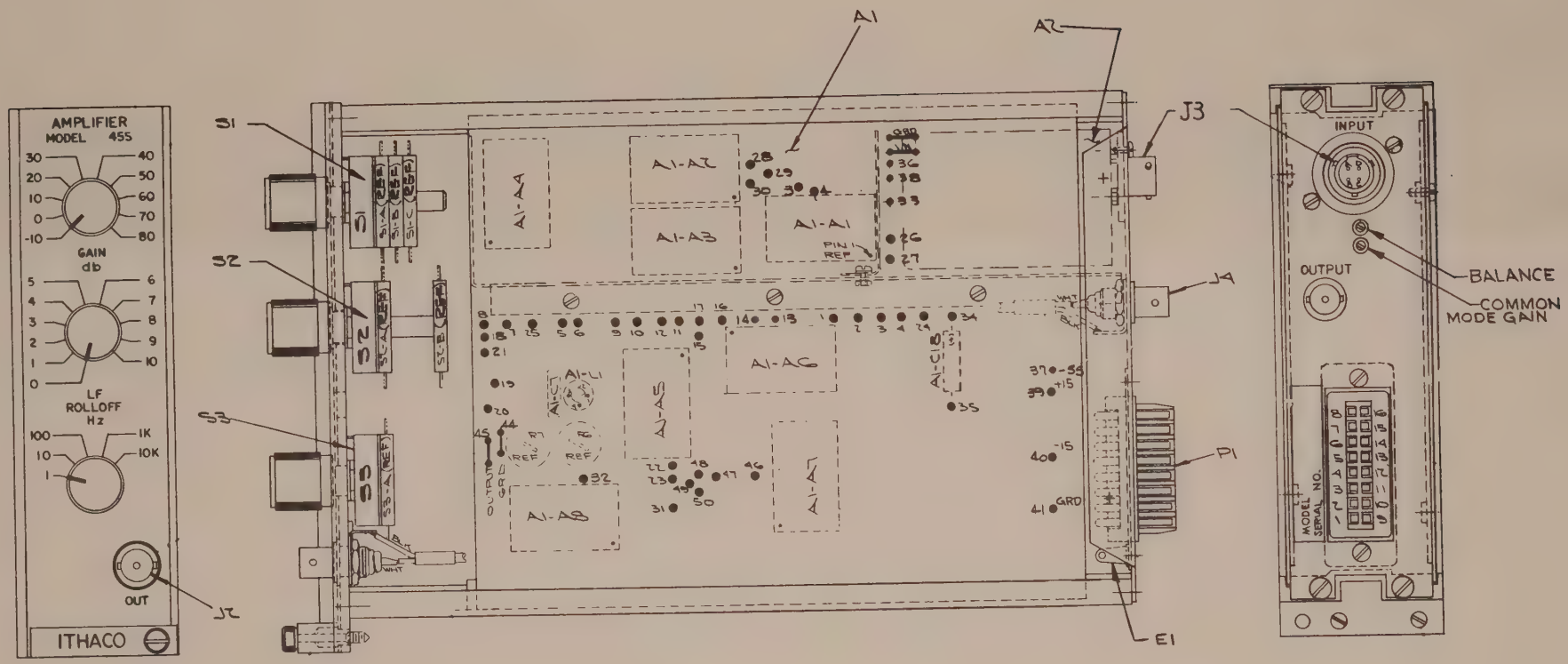


MODEL 453 AMPLIFIER
ASSEMBLY

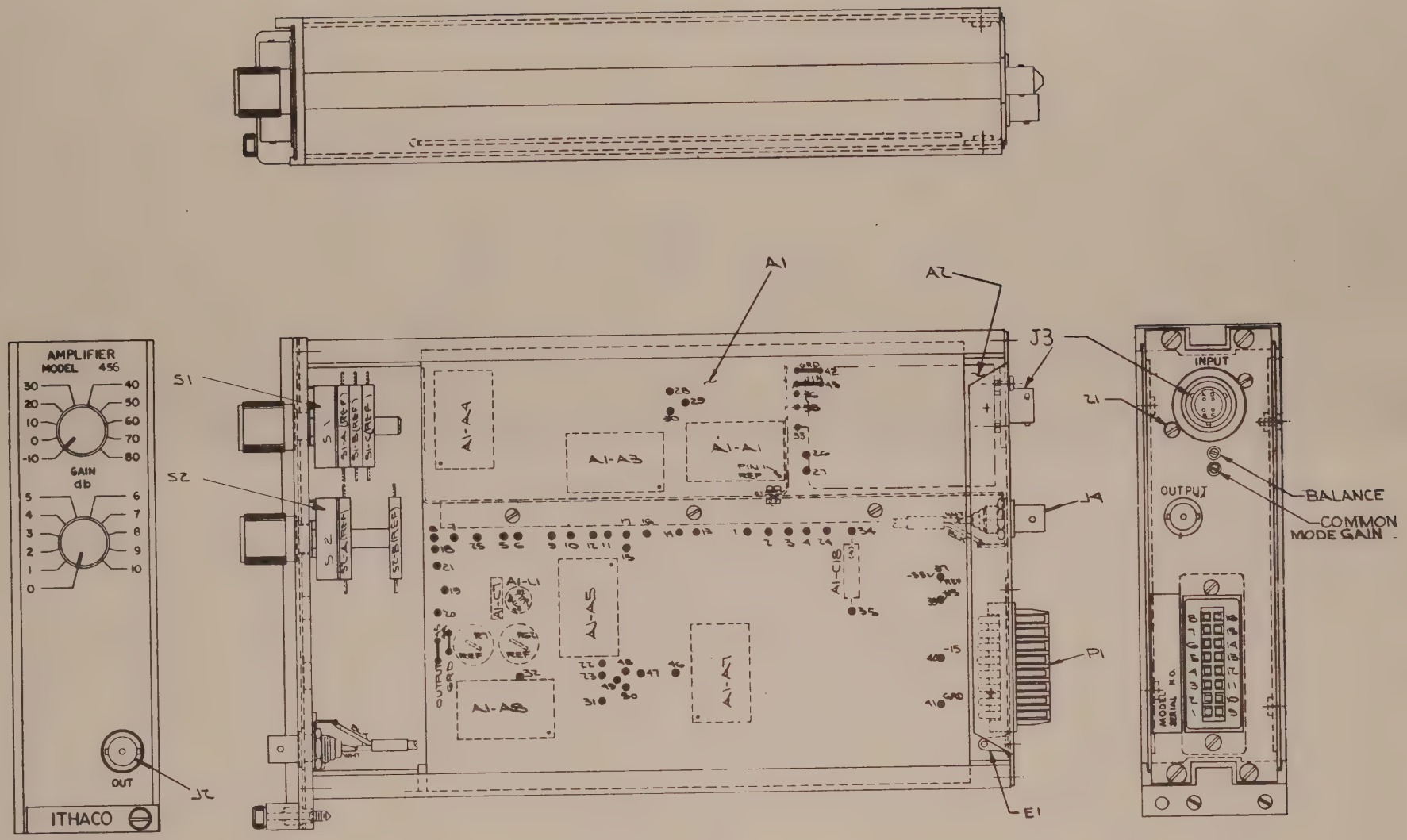


MODEL 454 AMPLIFIER
ASSEMBLY





MODEL 455 AMPLIFIER
ASSEMBLY



MODEL 456 AMPLIFIER
ASSEMBLY

GRD

INPUT

C1

A2 REF ROLLOFF

A3 REF 1ST

A4 INPUT REF

AA 2ND A&A II REF

C12

C13

R10

R9

R11

R12

R14

R115

R116

C4

C3

R17

R18

R123

RT2

A5 2ND A&A II REF

R20

R19

R4

R6

R7

R8

R22

R27

RT1

A8 REF OUTPUT

LFRO AC REF

A7 REF P.I.

C11

C9

C10

C8

C5

C6

C14

CR1

CR2

C15

CR3

C18 REF

CR4

-55V

+15V

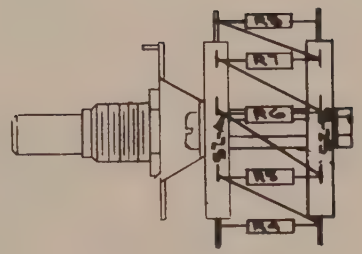
-15V

GRD

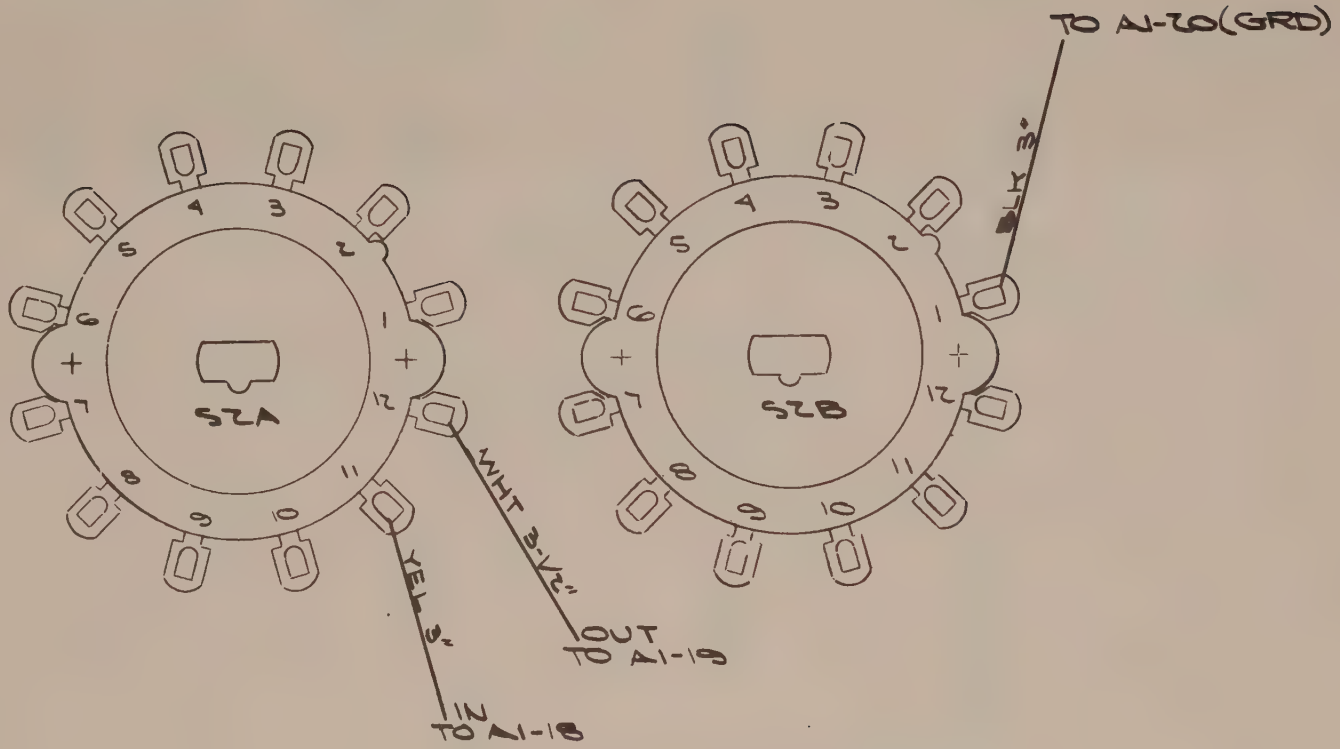
GRD

OUTPUT

450 SERIES
MOTHERBOARD ASSEMBLY

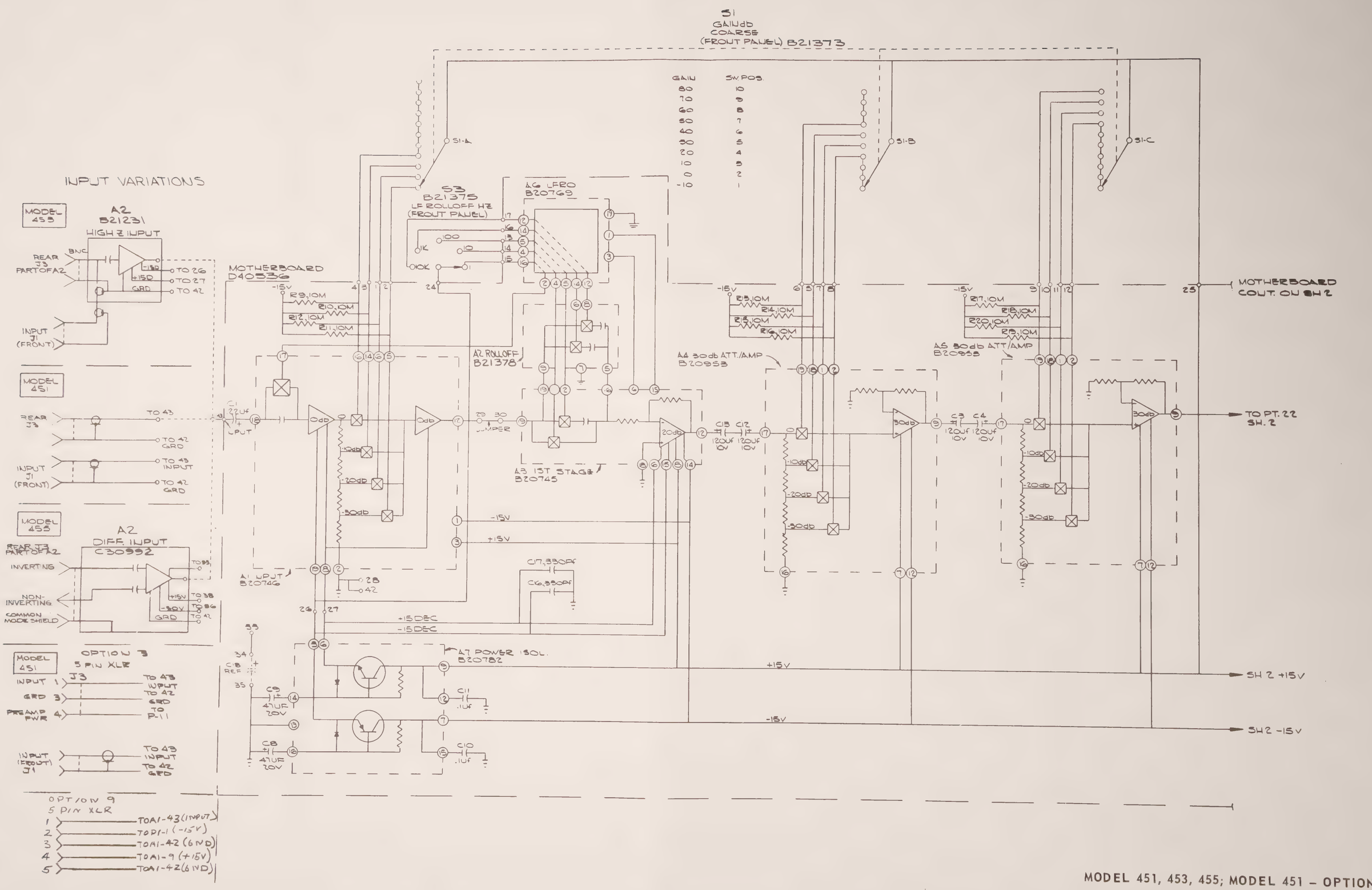


← A

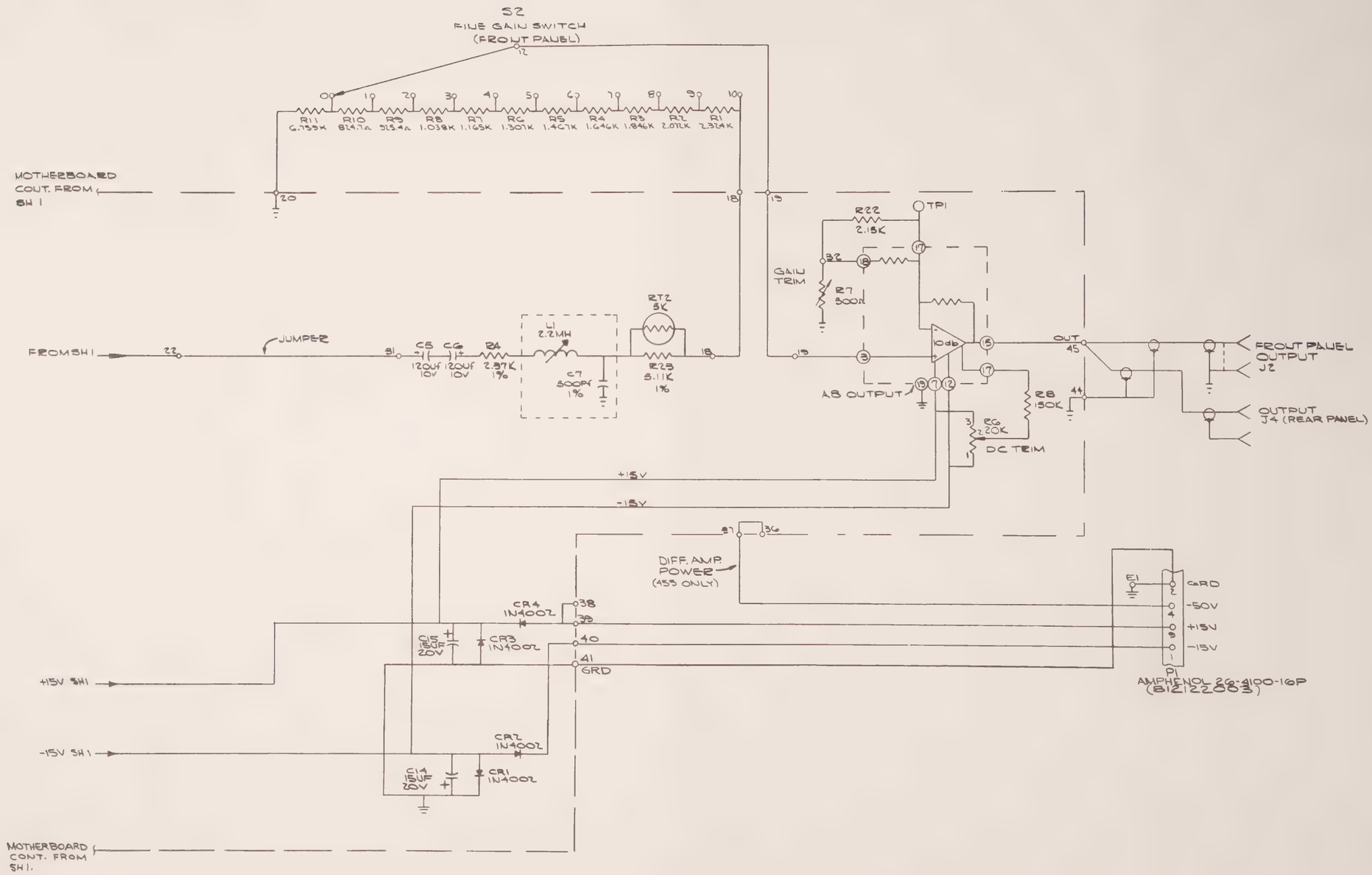


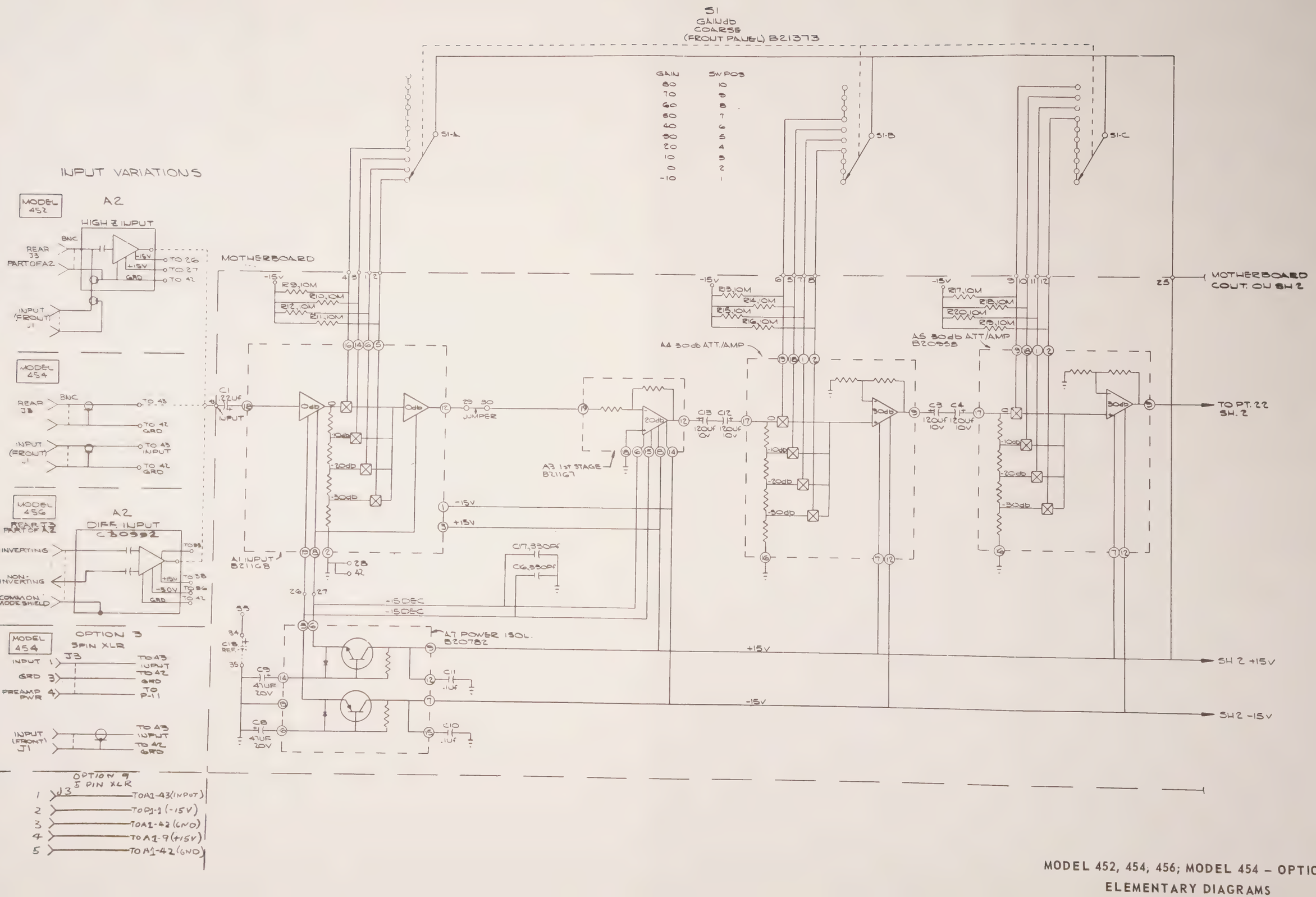
VIEW AT "A" ENLARGED

1 dB STEP ATTENUATOR
ASSEMBLY

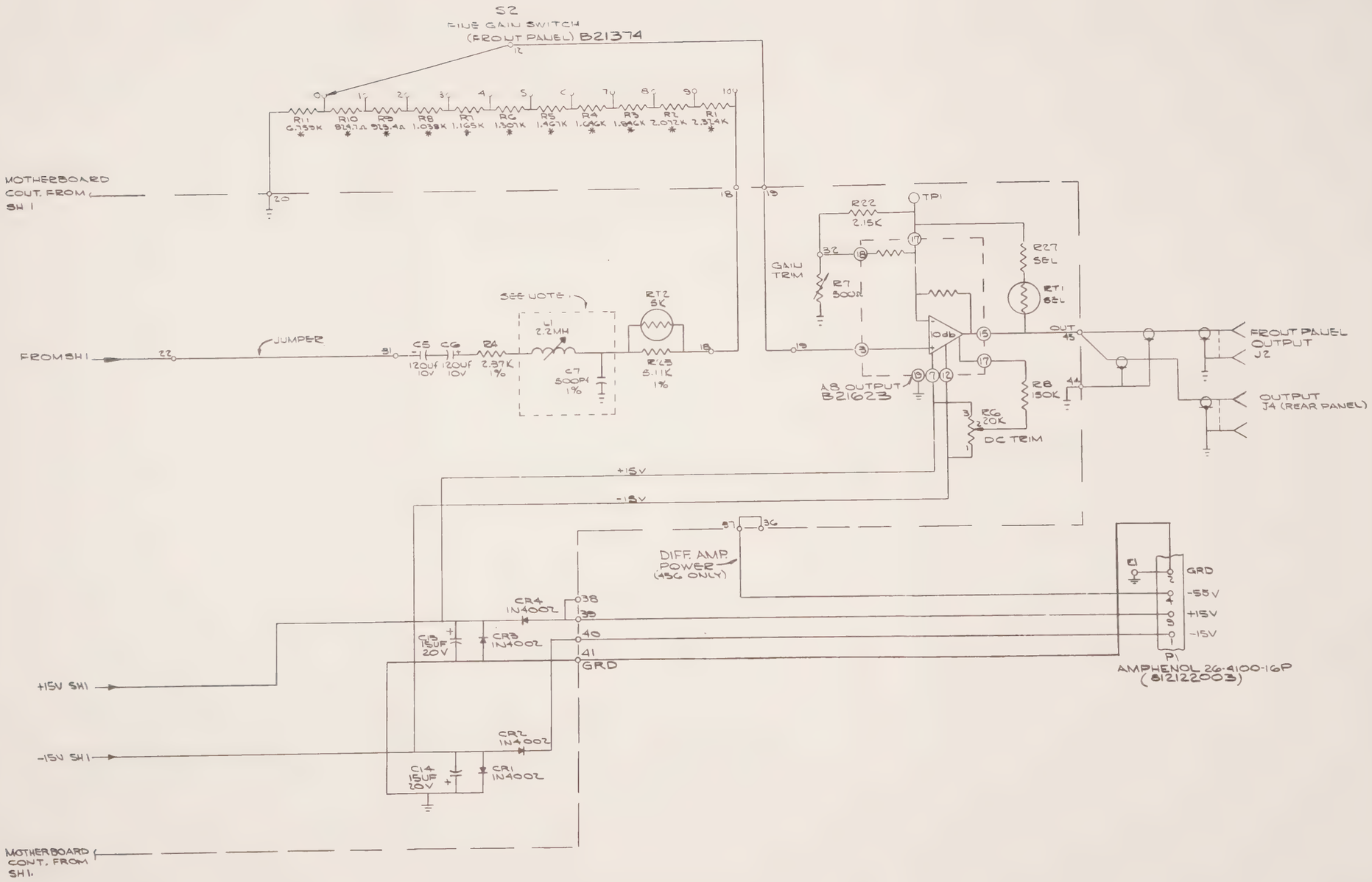


MODEL 451, 453, 455; MODEL 451 – OPTION 3
ELEMENTARY DIAGRAMS


S2
FINE GAIN SWITCH
(FRONT PANEL)
12
0 1 2 3 4 5 6 7 8 9 10
R11 6.755K
R10 814.7Ω
R9 515.4Ω
R8 1.038K
R7 1.165K
R6 1.307K
R5 1.467K
R4 1.646K
R3 1.846K
R2 2.072K
R1 2.324K
MOTHERBOARD CONT. FROM SH 1
20
18
19
R22 2.15K
TP1
17
32
18
GAIN TRIM
R7 500Ω
FROM SH 1
22
JUMPER
31
C5 12UF 10V
C6 12UF 10V
R4 2.37K 1%
L1 2.2MH
C7 500PF 1%
RT2 5K
R23 5.11K 1%
18
19
3
10db
5
17
OUT
45
AB OUTPUT
19
7
12
R8 150K
44
FRONT PANEL OUTPUT J2
OUTPUT J4 (REAR PANEL)
3
R6 2.20K
1
DC TRIM
+15V
-15V
37
36
DIFF. AMP. POWER (453 ONLY)
E1
GRD
-50V
+15V
-15V
P1
AMPHENOL 26-4100-16P
(812-22083)
CR4 IN4002
38
39
C5 12UF 20V
CR3 IN4002
40
41
GRD
+15V SH1
CR2 IN4002
-15V SH1
C6 12UF 20V
CR1 IN4002
MOTHERBOARD CONT. FROM SH1.



MODEL 452, 454, 456; MODEL 454 – OPTION 3
ELEMENTARY DIAGRAMS



NOTES:
1. L1 & C7 SHOWN FOR STD. 100 K Hz ROLLOFF
3. RESISTORS MARKED * ARE ¼W, 0.1%

REV. NO.	TITLE
A12718 G1	MODIFICATION INSTRUCTION AMPLIFIER MODEL 454 M125
	FIRST MADE FOR

REVISIONS

SCOPE: THIS DOCUMENT IS ESTABLISHED AS A SOURCE OF INFORMATION FOR THE PURPOSE OF DEFINING A 454M125.

DEFINITION: THE MODEL 454M125 CONSISTS OF:

1 OPTION 04 - WHICH CONSTITUTES THE ADDITION OF A METER CALIBRATED IN TERM OF RMS VOLTS FOR A SINE WAVE AND AN AVERAGE DETECTOR MEASURING THE AMPLIFIER'S OUTPUT.

2 OPTION 09 - WHICH INCLUDES THE ADDITION OF A 5 PIN XLR CONNECTOR THROUGH WHICH PREAMP POWER ± 15V AND AMPLIFIER INPUT ARE ROUTED. SEE NOTE ⚠1

3 OPTION 05 - WHICH CHANGES THE LOW FREQUENCY CUT OFF TO 10HZ.

4 OPTION 06 - WHICH CHANGES THE HIGH FREQUENCY CUT OFF TO 20KHZ.

GENERAL: CONTAINED HEREIN IS A LIST OF DELETED ITEMS, A LIST OF ADDED ITEMS AND INSTRUCTIONS.

REFERENCE DRAWINGS:
D40536-G1 ASSY, MOTHERBOARD
D40456 ELEM DIAG 450 SERIES
C30641-G1 ASSY, MODEL 454
A11170G1 OPT 04
A12082G1 OPT 09

NOTE:

⚠1. IN SOME CASES IT MAY BE DESIRABLE TO USE +28V TO OPERATE ITHACO 140 SERIES PREAMPLIFIERS. WHEN EITHER A P12,P13 OR P33 POWER SUPPLY IS PRESENT +28 APPEARS ON P1-11. AT USER OPTION A SINGLE GROUND PIN MAY BE USED ON J3 (XLR) WITH +28V BEING CONNECTED FROM P1-11 IN LIEU OF ONE OF THE GROUNDS. ALTERNATIVELY J3-4 MAY BE REWIRED TO HAVE +28V. THIS WOULD ONLY BE DONE IF THERE WERE NO INTENTION OF USING A PREAMPLIFIER REQUIRING ±15 VOLTS.

A1

PRINTS TO

MADE BY	APPROVALS		
ISSUED			A12718 G1 SHT 1 OF 2

ITH-21M

ITHACO, INC. ITHACA, N. Y.

REV. NO.	TITLE
A12718 G1	MODIFICATION INSTRUCTION AMPLIFIER MODEL 454M125
	FIRST MADE FOR

SHT 2 OF 2

REVISIONS

LIST OF PARTS TO BE DELETED

ITEM	IDENT	DESCRIPTION	QTY
FROM ASSY MOTHERBOARD D40536-G1			
C1	811553008	CAPACITOR, .22UF, 200V, 10%	1
R4	817211237	RESISTOR, 2.37K, 1/8W, 1%	1
FROM MAJOR ASSY AMPLIFIER, C30641-G1			
A1-C7	811581015	CAPACITOR, 500pf, 1%	1
A1-L1	811800003	CHOKE, VAR., 1.76mh TO 2.63mh	1

LIST OF PARTS TO BE ADDED

TO ASSY MOTHERBOARD D40536-G1			
C1	811540068	CAPACITOR, .016UF, 200V, 1%	1
R4	817261120	RESISTOR, 2.251K, 1/8W, 0.1%	1
TO MAJOR ASSY, AMPLIFIER, C30641-G1			
A1-C7	811540054	CAPACITOR, .005UF, 400V, 1%	1
A1-L1	811800006	CHOKE, VAR., 8.0mh TO 12mh	1

INSTRUCTIONS

1. INSTALL OPTION 04 PER A11170-G1
2. INSTALL OPTION 09 PER A12082-G1
3. REPLACE C1, R4, A1-C7 & A1-L1 WITH NEW VALUES PER LISTS ABOVE.
4. INSTALL SERIAL LABEL A11064-P1 INDICATING MODEL 454 M 125
5. TEST UNIT FOR -3dB ± 0.2dB AT 10Hz (OPT 05) AND ADJUST CHOKE L1 FOR -3dB AT 21.9KHZ. MEASURE THE PHASE SHIFT AT 10KHz. EXPECTED PHASE SHIFT IS 137.88° MAX, 135.88° MIN. READJUST L1 IF NECESSARY. IF L1 IS ADJUSTED VERIFY -3.0 ± 0.2 dB AT 21.9KHz.
   TEST OPTIONS 04 & 09 IN USUAL MANNER

A1
PRINTS TO

MADE BY	APPROVALS		
W. THURSTON 2-2382			A12718 G1
ISSUED			SHT 2 OF 2

ITH-21M

ITHACO, INC. ITHACA, N.Y.

A12082 SH 1 OF 5	COVER SHEET FOR AMPLIFIER OPTION 09 FIRST MADE FOR 66731

REVISION STATUS OF SHEETS				REV	AUTHORITY	APP	DATE
SHEET	STATUS	SHEET	STATUS				
1	D	11		A	ADDED J4(MATE FOR J3) DBullen 9-19-77	DWS	9-21-77
2	---	12		B	ECN 2911 JS 11-14-77	DWS	11-15-77
3	D	13		C	ADDED WIRE LGTHS & COLORS DB 7-17-79	WGT	7-17-79
4	C	14		D	ECN 4211 WGT 6-3-81	WGT	6-3-81
5	---	15					
6		16					
7		17					
8		18					
9		19					
10		20					

G1 451-09

G2 454-09

A10-1
A10-2
A10-4
A1

PRINTS TO

MADE BY DBullen Aug 17, 1977 ISSUED August 18, 1977	APPROVALS DWS		CODE IDENT. NO. 26502	A12082 SHEET 1 OF 5

REV. NO.	TITLE
A12082	AMPLIFIER OPTION 09
	FIRST MADE FOR 66731 SHT 2 OF 5

REVISIONS

SCOPE: THIS DOCUMENT IS ESTABLISHED AS A SOURCE OF INFORMATION FOR THE PURPOSE OF INCLUDING AN OPTION IN A STANDARD MODEL AMPLIFIER.

DEFINITION: OPTION 09 IS THE INCLUSION OF A 5 PIN XLR CONNECTOR THROUGH WHICH PREAMP POWER ($\pm$15V) AND AMPLIFIER INPUT ARE ROUTED. THIS OPTION IS AVAILABLE ON 451 OR 454 ONLY.

GENERAL: THE FOLLOWING TEXT CONTAINS A LIST OF ITEMS TO BE DELETED FROM AN EXISTING STANDARD MODEL AMPLIFIER AND A PARTS LIST OF ITEMS EITHER TO REPLACE DELETED PARTS OR TO BE ADDED TO THE UNIT IN A PREDETERMINED LOCATION. MECHANICAL PARTS ARE DESIGNED TO ACCEPT ALL OPTIONS. ALSO CONTAINED ARE DETAILED VIEWS OF AREAS TO HAVE DELETIONS, CHANGES, OR ADDITIONS.

REF. DWG'S:

C30561 G1	ASM, AMPLIFIER MODEL 451
D40455	ELEM, DIAG. MODEL 451
C30641 G1	ASM, AMPLIFIER MODEL 454
D40456	ELEM, DIAG. MODEL 454

PRINTS TO

MADE BY	APPROVALS		A12082
Aug. 17, 1977	VP DWS		SHT 2 OF 5
ISSUED August 18, 1977			

REV. NO.	TITLE
A12082	AMPLIFIER OPTION 09
	FIRST MADE FOR 450 SERIES

REVISIONS

A	ADDED J4 JB 9-19-77	ECN 4211 WT 6-3-81
D	9-21-77	WT 6-3-81

LIST OF DELETIONS

(FROM FINAL MODEL ASM)

ITEM	IDENT NO.	DESCRIPTION	QTY
J3	A10457 G1	ASM, CONNECTOR	1
22	A11064 P1	LABEL, SERIAL	1

G1 LIST OF ITEMS REQUIRED FOR 451-09

J3	812123006	XLR CONN.	1
22	A11064 P1	LABEL, SERIAL	1
100	812813412	SCR FLAT HD, #4-40 X 3/8	2
101	812841114	L'WASHER, #4	2
102	812831114	NUT, HEX #4-40	2
J4	812123005	MATE FOR J3	1
A1	C30561 G1	ASM MODEL 451	1

G2 LIST OF ITEMS REQUIRED FOR 454-09

A1	C30641 G1	ASM, MODEL 454	1
J3	812123006	XLR CONN	1
22	A11064 P1	LABEL, SERIAL	1
100	812813412	SCR FLAT HD #4-40 X 3/8	2
101	812841114	L'WASHER #4	2
102	812831114	NUT, HEX #4-40	2
J4	812123005	MATE FOR J3	1

PRINTS TO

MADE BY	APPROVALS		
Aug. 12, 1977	VR DWL		A12082 SHT 3 OF 5
ISSUED August 18, 1977			

REV. NO.	TITLE
A12082	AMPLIFIER OPTION 09
	FIRST MADE FOR 66731 SHT 4 OF 5

REVISIONS

B ECN 2511 11-14-77 JTS	J3-5 WAS A1-42 DH 7-12-79
	C 7-12-79

INSTRUCTIONS

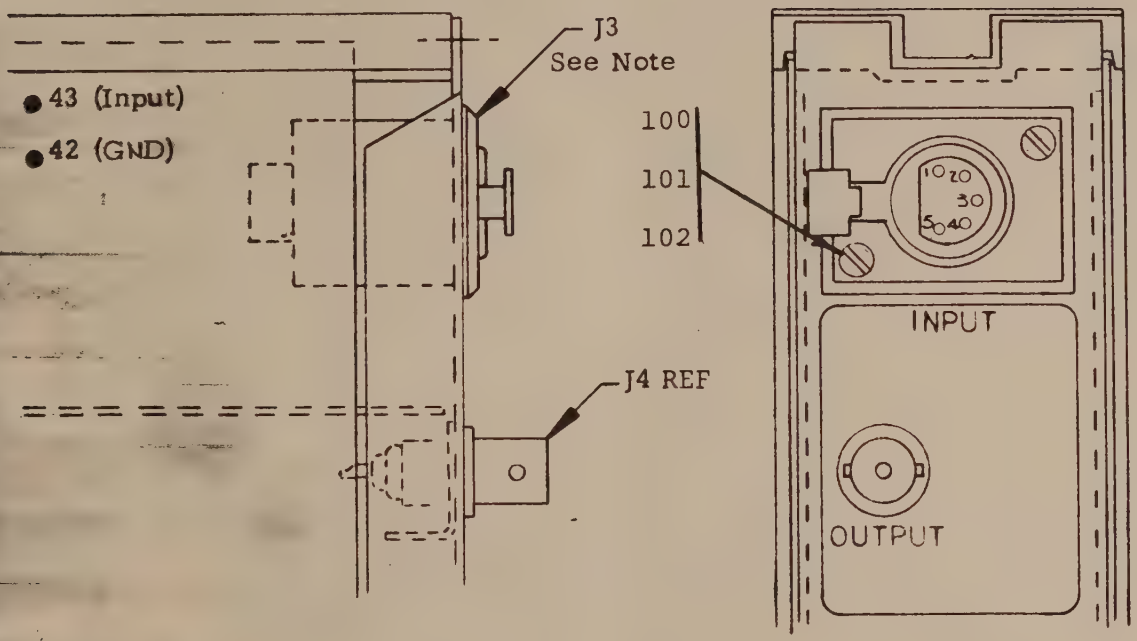
1. REPLACE A10457 G1 WITH 8121Z3006 AS SHOWN ON SHEET 5.
2. CONNECT J3-1 TO A1-43. (INPUT) WHT, 2 3/4" LG
3. CONNECT J3-3 TO J3-5, (GND) BLK, 1 1/2" LG
4. CONNECT J3-5 TO A1-42. (GND) BLK, 2 3/4" LG
5. CONNECT J3-4 TO P1-9 (+15V) RED, 6 1/2" LG
6. CONNECT J3-2 TO P1-1 (-15V) V10, 7" LG
7. REPLACE REAR PANEL SERIAL LABEL A11064 P1 WITH NEW LABEL. TYPE IN MODEL NO. TO WHICH OPTION IS BEING ADDED FOLLOWED BY 09.

PRINTS TO

MADE BY	APPROVALS		
Aug. 12 1977			A12082
ISSUED August 18, 1977			SHT 4 OF 5

REV. NO.	TITLE
A12082	AMPLIFIER OPTION -09
CONT. ON SHEET F SH. NO. 5	FIRST MADE FOR 450 SERIES

REVISIONS



PRINTS TO

MADE BY	APPROVALS		
August 17, 1977	V.L.		A12082
ISSUED August 18, 1977	DWL		CONT. ON SHEET F SH. NO. 5

ITHACO, INC. ITHACA, N.Y.

A11170 G1	COVER SHEET FOR: ASM, INSTRUCTIONS AMPLIFIER OPTION 04
SH. 1 OF 10	FIRST MADE FOR 30-2650

REVISION STATUS OF SHEETS				REV	AUTHORITY	APP	DATE
SHEET	STATUS	SHEET	STATUS	C	ADDED LEAD SH. FORMAT OBrown 1-9-78	DWS OB	1-9-78
1	D	//////////	////////	D	ECN 3024 JK 3-15-78	WGT	3-31-78
2	C	12					
3	D	13					
4	D	14					
5	---	15					
6	D	16					
7	D	17					
8	---	18					
9	---	19					
10	---	20					

SCOPE: THIS DOCUMENT IS ESTABLISHED AS A SOURCE OF INFORMATION FOR FOR THE PURPOSE OF INCLUDING AN OPTION IN A 450 SERIES AMPLIFIER.

DEFINITION: OPTION 04 CONSTITUTES THE ADDITION OF A METER CALIBRATED IN TERMS OF RMS VOLTS FOR A SINE WAVE AND AN AVERAGE DETECTOR MEASURING THE AMPLIFIERS OUTPUT. THIS OPTION IS AVAILABLE IN MODELS 452 (ASM, DWG. NO. C30694 G1), 454 (ASM DWG NO. C30641 G1), AND 456 (ASM, DWG. NO. C30715 G1) ONLY.

GENERAL: CONTAINED HERE-IN IS A LIST OF INSTRUCTIONS, VIEWS SHOWING THE AREAS OF CHANGE, A WIRING DIAG., AND A RUNNING LIST.

REF. DWG'S:

C30694 G1	ASM, MODEL 452 AMPLIFIER
C30641 G1	ASM, MODEL 454 AMPLIFIER
C30715 G1	ASM, MODEL 456 AMPLIFIER
D40456	ELEM, DIAG. MODEL 452, 454 & 456
C30816 G3	ASM, METER DETECTOR CARD
C31484	ELEM, DIAG. METER DETECTOR
B20940 SH 3	RAIL, BOTTOM
C31026 SH.31	PANEL, EXTRUDED
A10301	ROD, CARD SPACER
A10302	SPRING, CARD RETAINING

A10-1
A10-2
A10-4
A1
PRINTS TO

MADE BY R.J.TINKER 2-25-72	APPROVALS ILF RAB		CODE IDENT. NO. 26502	A11170
ISSUED FEB. 29 1972				SHEET 1 OF 10

REV. NO.	TITLE
A11170	ASM INSTRUCTIONS AMPLIFIER OPTION 04
CONT. ON SHEET 3 SH. NO. 2	FIRST MADE FOR 30-2650

REVISIONS

U	DELETED ITEM 3 PW1 CROSSED OUT IN 3 PLACES 1-9-18

LIST OF PARTS TO BE DELETED

FROM C30694G1 (MODEL 452)

ITEM	IDENT. NO.	DESCRIPTION	QTY
3	B21177P2	Front Panel	1

FROM C30641G1 (MODEL 454)

3	B21177P1	Front Panel	1

FROM C30715G1 (MODEL 456)

3	B21324P1	Front Panel	1

PRINTS TO

A1
A10-2
A10-4

MADE BY	APPROVALS		
R.J. Tinker 2-25-72			A11170
ISSUED Feb. 29, 1972			CONT. ON SHEET 3 SH. NO. 2

ITH-21

REV. NO.	TITLE	SHT	OF
A11170	ASM, INSTRUCTIONS AMPLIFIER OPTION 04 FIRST MADE FOR 30-2650	3	10

REVISIONS

DELETED ITEM 51 C30686P1 SHLD CARD 2 PCS ECN 3024 1-9-78 DAT 3-31-78
UK 3-15-78
V D

LIST OF PARTS TO BE ADDED

TO C30694 G1 (MODEL 452)

ITEM	IDENT NO.	DESCRIPTION	QTY
A2	C30816 G3	ASM, METER DETECTOR	1
M1	B88212 P1	METER, 0-1 MA DC, DIAL MODIFIED TO READ 0-2 V RMS	1
50	B21177 P2 MODIFIED PER SHEET 8	FRONT PANEL	1
52	A10302 P1	SPRING, CARD RETAINING	1
53	812800301	#6 GROUND LUG	2

TO C30641 G1 (MODEL 454)

ITEM	IDENT NO.	DESCRIPTION	QTY
A2	C30816 G3	ASM, METER DETECTOR	1
M1	B88212 P1	METER, 0-1 MA DC, DIAL MODIFIED TO READ 0-2 V RMS	
50	B21177 P1 MODIFIED PER SHEET 8	FRONT PANEL	1
52	A10302 P1	SPRING, CARD RETAINING	1
53	812800301	#6 GROUND LUG	2

TO C30715 G1 (MODEL 456)

ITEM	IDENT NO.	DESCRIPTION	QTY
A2	C30816 G3	ASM, METER DETECTOR	1
M1	B88212 P1	METER, 0-1 MA DC, DIAL MODIFIED TO READ 0-2 V RMS	
50	B21324 P1 MODIFIED PER SHEET 8	FRONT PANEL	1
52	A10302 P1	SPRING, CARD RETAINING	1
53	812800301	#6 GROUND LUG	2

A10-2
A10-2

PRINTS TO

MADE BY	APPROVALS		
R.J.TINKER 2-25-72	ILF		A11170
ISSUED FEB.29 1972	RAB		SHT 3 OF 10

REV. NO.	TITLE
A11170 CONT. ON SHEET 5 SH. NO. 4	ASM INSTRUCTIONS AMPLIFIER OPTION 04 FIRST MADE FOR 30-2650

REVISIONS

C	DELETED REPLACE SHIELD (STEP NOTE 3)	1-9-78
D	ECN 3024 JR 3-15-78	

LIST OF PARTS TO BE DELETED FROM C30692G1 BASIC ASM

ITEM	IDENT. NO.	DESCRIPTION	QTY
2	C31026P4	Panel, Extruded	1

LIST OF PARTS TO BE ADDED TO C30692G1 BASIC ASM

100	C31026P31	Panel, Extruded	1

INSTRUCTIONS FOR C30692G1 BASIC ASM

1. Replace extruded panel Item 2 (C31026P4) with item 100 (C31026P31).

INSTRUCTIONS FOR MAJOR ASSEMBLY

1. Replace front panel Item 3 with a modified front panel as shown on sheet 5.

3. Add meter (M1) to front panel.

4. Add meter detector card (A2) and retaining spring (Item 52) as shown on sheet 6.

5. Wire per attached diag. & R.L.

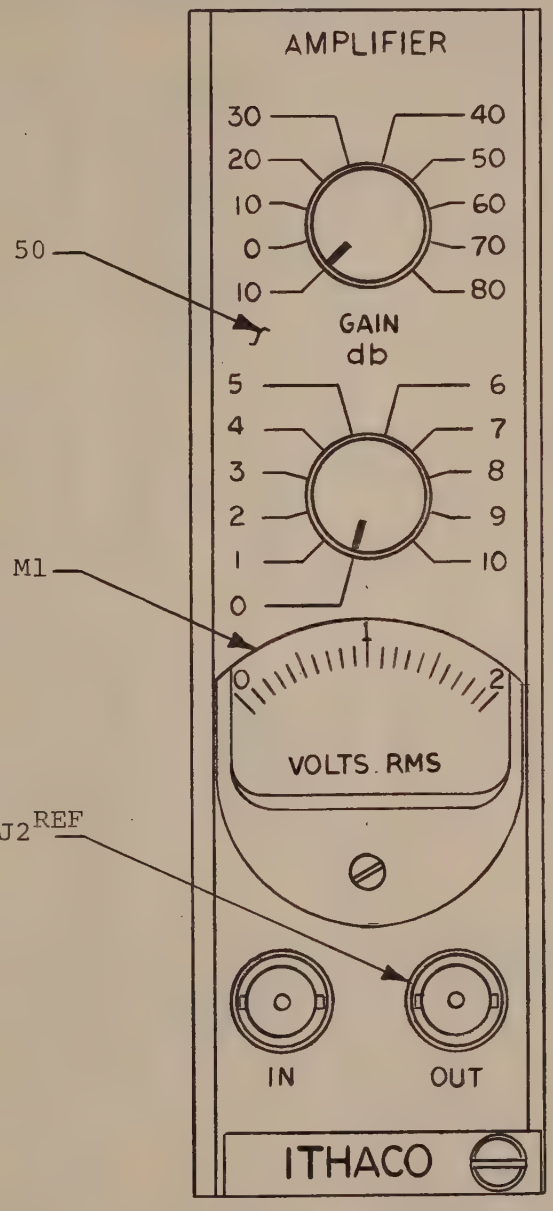
PRINTS TO
A1
A10-2
A10-4

MADE BY	APPROVALS		
R.J. Tinker 2-25-72			A11170
ISSUED Feb. 29, 1972			CONT. ON SHEET 5 SH. NO. 4

ITH-21

REV. NO.	TITLE
A11170	ASM INSTRUCTIONS AMPLIFIER OPTION 04
	FIRST MADE FOR 30-2650 SHT 5 OF 10

REVISIONS



C30641G1

FRONT VIEW

With Option-04
Meter Added

			MAT'L:
			FIN:
			SCALE:
			UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .010 ANGLES ± 1/2°
REFERENCE DWG		USED ON	
APPLICATION			

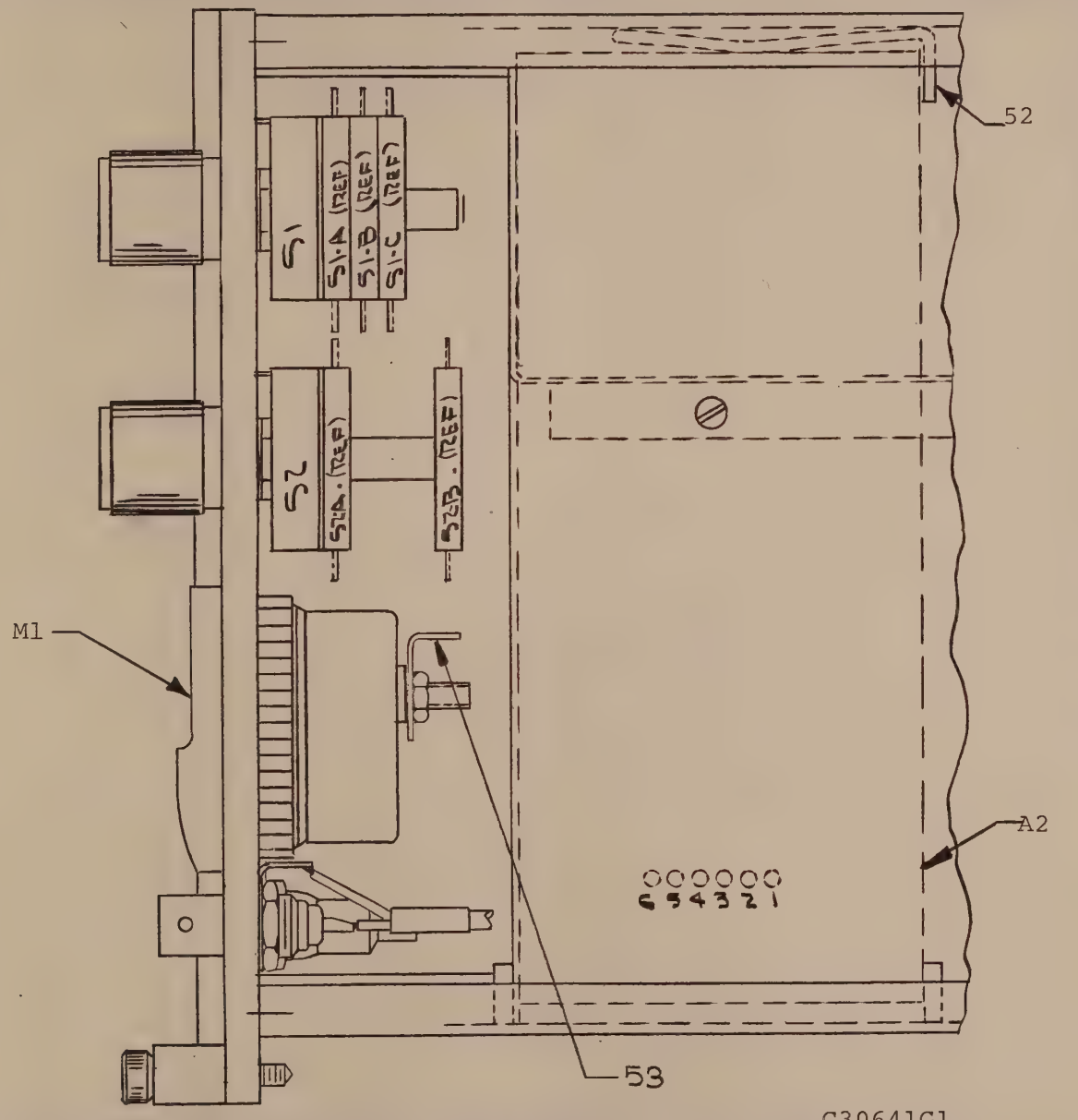
PRINTS TO
A10-2
A10-4
A5
A1

MADE BY	APPROVALS		
R.J.Tinker 2-25-72			A11170 SHT 5 OF 10
ISSUED Feb. 29, 1972			

ITH-21M

ITHACO, INC. ITHACA, N. Y.

REV. NO.	TITLE
A11170	ASM INSTRUCTIONS AMPLIFIER OPTION 04
	FIRST MADE FOR 30-2650 SHT 6 OF 10



REVISIONS

C	DELETED ITEM 53 (SIGNAL CABLE) (SHOWN ON DWG)	1-9-78
D	ECN 3024 JK 3-15-78	WHT 3-31-78

C30641G1
SIDE VIEW

WITH
OPTION 04
ADDED

MAT'L:	
FIN:	
SCALE:	
REFERENCE DWG	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS ± 1/64 DECIMALS ± .010 ANGLES ± 1/2°

A10-2
A10-1
A5
A1

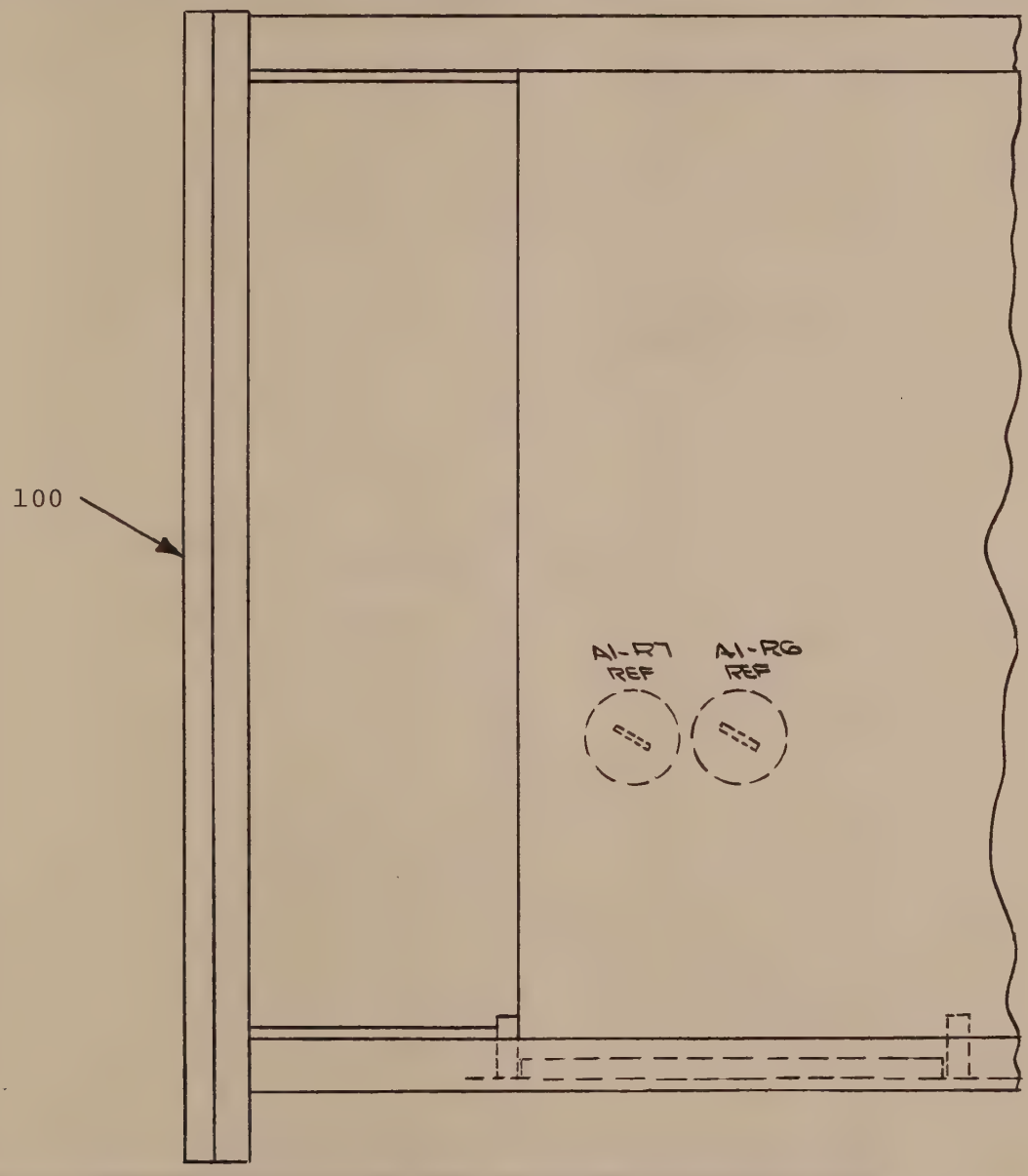
PRINTS TO

MADE BY	APPROVALS		
R.J.Tinker 2-25-72			A11170 SHT 6 OF 10
ISSUED Feb. 29, 1972			

ITH-21M

ITHACO, INC. ITHACA, N. Y.

REV. NO.	TITLE
A11170	ASM INSTRUCTIONS AMPLIFIER OPTION 04
	FIRST MADE FOR 30-2650 SHT 7 OF 10



REVISIONS

D	ECN 3024 JK 3-30-78	WHT 3-31-78	

		MAT'L:	C30692G1
		FIN:	SIDE VIEW
		SCALE:	WITH OPTION 04 ADDED
REFERENCE DWG	USED ON	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .010 ANGLES ± 1/2°	
APPLICATION			

A10-2
A10-4
A5
A1
PRINTS TO

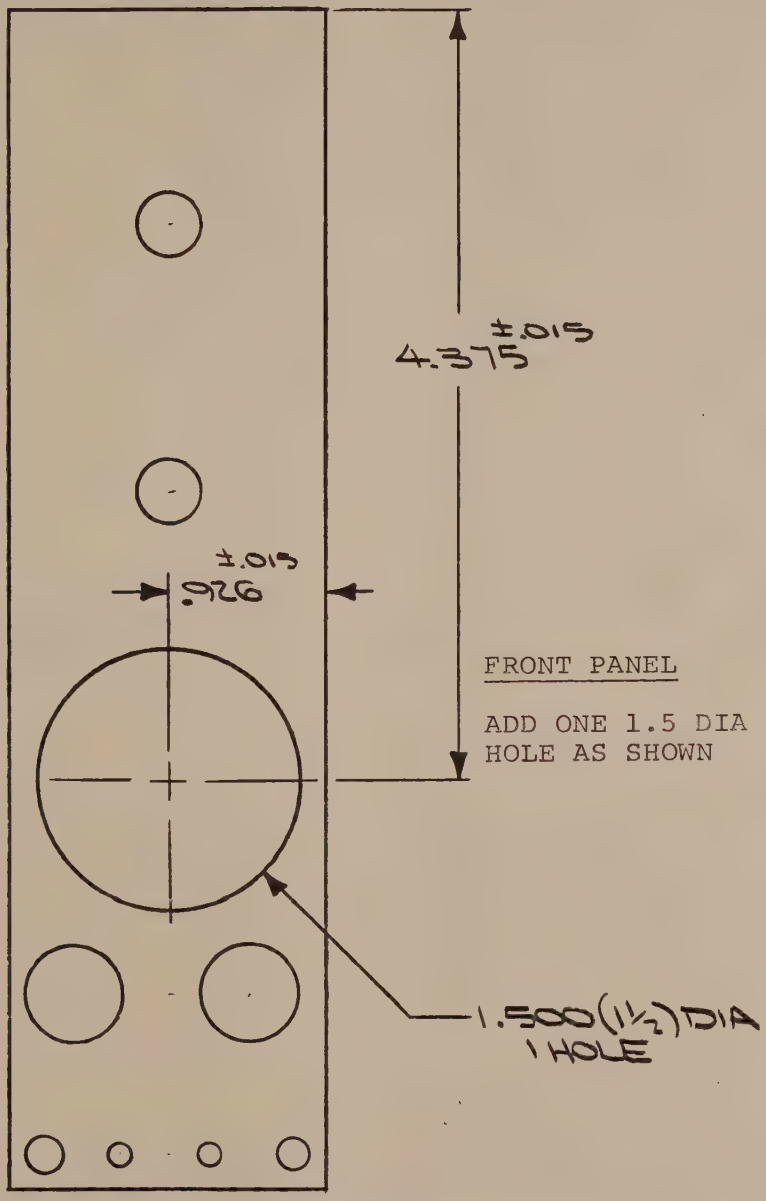
MADE BY R.J.Tinker 2-25-72	APPROVALS		A11170 SHT 7 OF 10
ISSUED Feb. 29, 1972			

ITH-21M

ITHACO, INC. ITHACA, N. Y.

REV. NO.	TITLE
A11170	ASM INSTRUCTIONS AMPLIFIER OPTION 04
	FIRST MADE FOR 30-2650 SHT 8 OF 10

REVISIONS



			MAT'L:
			FIN:
			SCALE:
			UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ± 1/64 ± .010 ± 1/2°
REFERENCE DWG	USED ON		
APPLICATION			

A10-2
A10-A
A5
A1
PRINTS TO

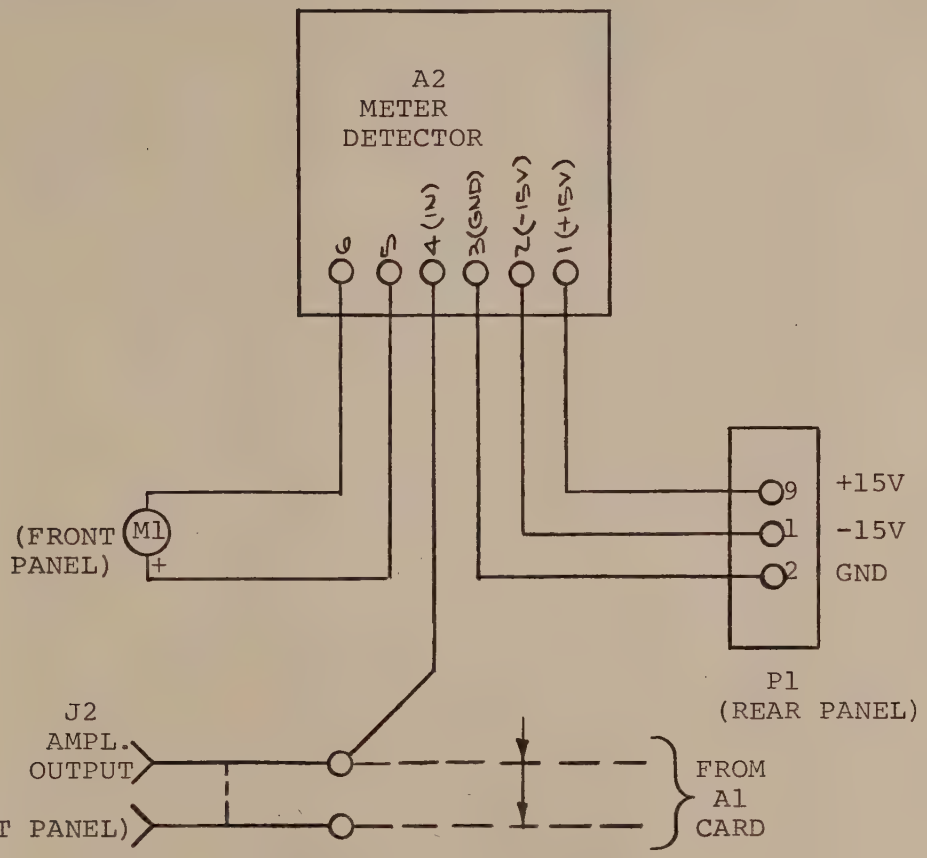
MADE BY	APPROVALS		
R.J.Tinker 2-25-72			A11170 SHT 8 OF 10
ISSUED Feb. 29, 1972			

ITH-21M

ITHACO, INC. ITHACA, N. Y.

REV. NO.	TITLE
A11170	ASM INSTRUCTIONS AMPLIFIER OPTION 04
	FIRST MADE FOR 30-2650 SHT 9 OF 10

REVISIONS



		MAT'L:	ELEM DIAG
		FIN:	A1
		SCALE:	450 SERIES A5
		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ± 1/64 ± .010 ± 1/2°	OPT 04 A10-2 A10-A
REFERENCE DWG	USED ON		
APPLICATION			PRINTS TO

MADE BY	APPROVALS		
R.J.Tinker 2-25-72			A11170 SHT 9 OF10
ISSUED Feb. 22, 1972			

ITH-21M

ITHACO, INC. ITHACA, N. Y.

REV NO. A11170

CONT. ON SHEET – SH. NO. 10

TITLE ASM INSTRUCTIONS
AMPLIFIER OPTION 04

FIRST MADE FOR 30-2650

WIRE NO	AWG	COLOR BODY	1st TRACER	Cable Routing	FROM	TO	FUNC.	LGTH
1	#24	BLU			M1 –	A2-6		5"
2	#24	ORN			M1 +	A2-5		5 1/4"
3	#24	YEL			J2-CTR	A2-4	OUTPUT	4 1/4"
4	#24	BLK			P1-2	A2-3	GND	9"
5	#24	VIO			P1-1	A2-2	-15V	8 1/2"
6	#24	RED			P1-9	A2-1	+15V	8 1/2"

REVISIONS

A Added Wire & LGTHS & CTR to W2 DJB 10-19-72

A10-2

A10-4

A5

A1

PRINTS TO

MADE BY R.J. Tinker 2-25-72

ISSUED March 8, 1972

APPROVALS

A11170

CONT. ON SHEET – SH. NO. 10

ITH-85 Rev. 9/71

SECTION 6

6.0 REPLACEABLE PARTS

6.1 INTRODUCTION

This section contains information for ordering replaceable parts. Tables list parts in alphabetical order of their reference designations and indicates the description and manufacturer's part number. When applicable, a typical manufacturer is indicated.

6.2 REFERENCE DESIGNATIONS AND ABBREVIATIONS

Table 6.1 is a list of reference designations and abbreviations.

6.3 CODE LIST OF MANUFACTURERS

Table 6.3 is a Code List of Manufacturers. The manufacturer's code is given with each part. If a code number is missing, the part is a standard designation and available from many manufacturers.

REFERENCE DESIGNATIONS

A	assembly subassembly, separable or repairable
AR	amplifier
AT	attenuator pad termination
B	blower motor synchro
BT	battery
C	capacitor
CB	circuit breaker
CP	adapter, connector coupling (aperture, loop or probe) junction (coaxial or waveguide)
CR	diode rectifier
DS	alarm indicator (excluding meter)
E	antenna arrester, lightning bimetallic strip cell, aluminum or electrolytic contact core, inductor core, memory core, transformer Hall effect device insulator loop antenna magnet, permanent part, miscellaneous electrical post, binding shield, electrical terminal (individual)
F	fuse
FL	filter
G	chopper, electronic generator
H	hardware
HR	heater lamp, infrared
HS	handset
HY	network, hybrid circuit
J	connector, receptacle, electrical disconnecting device jack receptacle (connector, stationary portion)
K	relay
L	coil (all not classified as transformers) inductor
M	clock counter, electrical meter oscillograph oscilloscope recorder, elapsed time register, message strain gage thermometer timer, electric
MK	microphone
MP	frame gyroscope interlock, mechanical mechanical part mounting (not electrical circuit, not a socket) part, miscellaneous mechanical (bearing, coupling, gear, shaft) part, structural reed, vibration tuning fork
MT	transducer transducer, mode
P	connector, plug, electrical disconnecting device (connector, plug) plug, electrical (connector, movable portion)
PS	power supply
Q	transistor
R	potentiometer resistor
RT	lamp, resistance resistor, current regulating resistor, thermal thermistor
RV	resistor, voltage sensitive varistor, symmetrical
S	switch thermostat
T	transformer
TB	strip, terminal terminal board
TC	thermocouple
TP	test point
U	integrated circuit package
V	cell, light-sensitive, photo-emissive electron tube
W	cable cable assembly (with connectors) wire
WT	tiepoint, wiring
X	fuseholder lampholder socket
Y	crystal unit, piezoelectric

ABBREVIATIONS

A	ampere
AC	alternating current
ALUM	aluminum
AMPL	amplifier
ASSY	assembly
BP	bandpass
CAL	calibration
CAR	carbon
CCW	counterclockwise
CER	ceramic
CKT	circuit
COMP	composition
CRT	cathode-ray tube
CW	clockwise
dB	decibel
DC	direct current
DET	detector
DVM	digital voltmeter
ELECT	electrolytic
ENCAP	encapsulated
EXT	external
F	farads
FET	field effect transistor
FREQ	frequency
FXD	fixed
GE	germanium
GL	glass
GND	ground
H	henries
HPF	high-pass filter
HR	hour
Hz	hertz
IF	intermediate frequency
INS	insulation(ed)
INT	internal
K	kilo = 1000
LED	light emitting diode
LIN	linear taper
LOG	logarithmic taper
LPF	low-pass filter
M	Millo 10^{-3}
MEG	meg 10^{6}
METFLM	metal film
MFR	manufacturer
MINAT	miniature
MOM	momentary
MTG	mounting
MYFLM	"mylar" film
N	nano (10^{-3})
N/C	normally closed
NE	neon
N/O	normally open
NPO	negative positive zero
NSR	not separately replaceable
OSC	oscillator
OP	operational
PC	printed circuit
PF	picofarads 10^{12} farads
PIV	peak inverse volt voltage
P/P	part of
PPM	parts per million
POLY	polystyrene
POLYCARB	poly carbonate
POS	position(s)
POT	potentiometer
P-P	peak-to-peak
RC	resistor capacitor network
RECT	rectifier
REF	reference
RF	radio frequency
RMS	root-means-square
S-B	slow-blow
SCR	screw
SE	selenium
SEC	second
SECT	section(s)
SEMICON	semiconductor
SI	silicon
SIL	silver
SL	slide
SOL	solid
SPL	special
TA	tantalum
TGL	toggle
TOL	tolerance
TRIM	trimmer
μ	micro 10^{-6}
V	volt
VAR	variable
VDCW	dc working volts
VCO	voltage controlled oscillator
W/	with
W	watts
WW	wirewound
W/O	without

TABLE 6.1 LIST OF REFERENCE DESIGNATIONS AND ABBREVIATIONS

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
	CAPACITORS			
C1	.22µF, 200V, 10%, Mylar	811553008	22	W230B1C-224K
C3	120µF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C4	120µF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C5	120µF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C6	120µF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C8	47µF, 20V, ±10%, Ta	811501162	48	150D476X9020R2
C9	47µF, 20V, ±10%, Ta	811501162	48	150D476X9020R2
C10	.1µF, 200V, 10%, Mylar	811553006	22	W230B1C-104K
C11	.1µF, 200V, 10%, Mylar	811553006	22	W230B1C-104K
C12	120µF, 10V, ±10%, Ta	811501075	48	150D127X9010R2
C13	120µF, 10V, ±10%, Ta	811501075	48	150D127X9010R2
C14	15µF, 20V, ±10%, Ta	811501156	48	150D156X9020B2
C15	15µF, 20V, ±10%, Ta	811501156	48	150D156X9020B2
C16	330pF, 1000V, ±10%, Cer	811572014	48	10TS-T33
C17	330pF, 1000V, ±10%, Cer	811572014	48	10TS-T33
	DIODES			
CR1	IN4005	818100007		IN4005
CR2	IN4005	818100007		IN4005
CR3	IN4005	818100007		IN4005
CR4	IN4005	818100007		IN4005
	RESISTORS			
	All resistors not otherwise designated are 1/4W, 5% Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R4	2.37K*	817211237		RN55D
R6	20K(Pot)	817803203	7	3386P-1-203
R7	500 ohm (Pot)	817803501	7	3386P-1-501
R8	150K	817007154		RC07
R9	10M	817007106		RC07
R10	10M	817007106		RC07

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
	RESISTORS (continued)			
R11	10M	817007106		RC07
R12	10M	817007106		RC07
R13	10M	817007106		RC07
R14	10M	817007106		RC07
R15	10M	817007106		RC07
R16	10M	817007106		RC07
R17	10M	817007106		RC07
R18	10M	817007106		RC07
R19	10M	817007106		RC07
R20	10M	817007106		RC07
R22	2.15K, *	817211215		RN55D
R23	5.11K, *	817211215		RN55D
R27	Resistor Opt			
RT1	Thermal Opt			
RT2	Thermal 5K	815300003	104	15-5K-54S1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B20746G1	31	B20746G1
A1-A2	Asm, Rolloff	B21378G1	31	B21378G1
A1-A3	Asm, 1st Stage	B20745G1	31	B20745G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2 nd Stage	B20953G1	31	B20953G1
A1-A6	Asm, LFRO Switch	B20769G1	31	B20769G1
A1-A7	Asm, Pow. Isol.	B20782G1	31	B21782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
A1-C7	Capacitor, 500pF, 500V, 1%, Sil Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J3	Asm, Connector, BNC	A10457G1	31	A10457G1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1
S3	Asm, Switch	B21375G1	31	B21375G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B21168G1	31	B21168G1
A1-A3	Asm, 1st Stage	B21167G1	31	B21167G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A7	Asm, Pwr Isol.	B20782G1	31	B20782G1
A1-A8	Asm, Output Stage	B21623G1	31	B21623G1
A1-C7	Capacitor 500pf, 500V, 1%, Sil Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
A2	Asm, High Z Input Stage	B21231G1	31	B21231G1
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1-A1	Asm, Input	B20746G1	31	B20746G1
A1-A2	Asm, Rolloff	B21378G1	31	B21378G1
A1-A3	Asm, 1st Stage	B20745G1	31	B20745G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A6	Asm, LFRO Switch	B20769G1	31	B20769G1
A1-A7	Asm, Pwr Isol	B20782G1	31	B20782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
A1-C7	Capacitor, 500pf, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
A2	Asm, High Z Input Stage	B21231G1	31	B21231G1
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1
S3	Asm, Switch	B21375G1	31	B21375G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1-A1	Asm, Input	B21168G1	31	B21168G1
A1-A3	Asm, 1st Stage	B21167G1	31	B21167G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A7	Asm,Pwr Isol	B20782G1	31	B20782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
A1-C7	Capacitor 500pF, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J3	Asm, Connector, BNC	A10457G1	31	A10457G1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	30	B21374G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1-A1	Asm, Input	B20746G1	31	B20746G1
A1-A2	Asm, Rolloff	B21378G1	31	B21378G1
A1-A3	Asm, 1st Stage	B20745G1	31	B20953G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A6	Asm, LFRO Switch	B20769G1	31	B20769G1
A1-A7	Asm, Pwr Isol	B20782G1	31	B20782G1
A1-A8	Asm, Output Stage	B21623G1	31	B21623G1
A1-C7	Capacitor, 500pf, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-C18	Capacitor, 100μF, 20V, ±10%, Ta	811501166	48	150D107X9020S2
A1-L1	Choke 2.2mH	811800003	10	3387-27
A2	Asm, Diff Input	C30992G2	31	C30992G2
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1
S3	Asm, Switch	B21375G1	31	B21375G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1-A1	Asm, Input	B21168G1	31	B21168G1
A1-A3	Asm, 1st Stage	B21167G1	31	B21167G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B21953G1
A1-A7	Asm, Pwr Isol	B20782G1	31	B21782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
	CAPACITORS			
A1-C7	500pF, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-C1	100μF, 20V, 10%, Ta	811501166	48	150D107X9020S2
A1-L1	Choke, 2.2mH	811800003	10	3387-27
A2	Asm, Diff Input	C30992G2		C30992G2
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1

CODE LIST OF MANUFACTURERS

1	Aerovox
2	Alco Electronic Prod
3	Allen Bradley
4	Amphenol Connector
5	Analog Devices
6	Belden
7	Bourns
8	Buckeye Stamping
9	Bussman Mfg
10	Cambion
11	Cannon, ITT
12	Centralab
13	Cinch Mfg
14	C & K Components
15	Continental– Wirt Elec
16	Corcom
17	Cornell Dubilier Elec
18	CTS
19	Dage Electric
20	Delevan Electronics
21	Dresser Systems
22	Electrocube
23	Electro Motive Mfg
24	Electronics Applications
25	Erie Technological Products
26	Fairchield Semiconductor
27	Federal Screw Prod
28	General Electric
29	Helipot
30	Heyman Mfg
31	ITHACO
32	E F Johnson
33	Litronix
34	Marco–Oak Industries
35	Motorola Semiconductor Prod
36	National Semiconductor
37	Ohmite Mfg
38	Paktron
39	Panduit
40	Pomona Electronics
41	Product Components
42	Pyrofilm
43	RCL Electronics
44	Rembrandt
45	Rogan
46	Schauer Mfg
47	H H Smith
48	Sprague Electric
49	Spectrol Electronics
50	Stancor
51	D M Steward Mfg
52	Switchcraft
53	Teledyne Semiconductor
54	Teledyne Western Wire and Cable
55	Texas Instruments
56	Thermalloy
57	TRW
58	United Transformer
59	Useco
60	Vactec
61	Winchester Electronic
62	Vishay
63	ACI
64	IRC
65	EAL
66	AMP
67	Clarostat Mfg
68	Gould Inc
69	Littlefuse Inc
70	General Illumination
71	Signetrics
72	Semiconductor Cir
73	Statek
74	Bendix
75	Burndy
76	American Handle Sales
77	Varo Semiconductor
78	Dialco
79	Elmenco
80	Amp Incorporated
81	Berg
82	Comp Corp
83	Hewlett–Packard
84	Beckman Helipot
85	Raytheon
86	Intersil
87	A H & H
88	ADC Products
89	Scanbe
90	Drake
91	Victoreen
92	Frost
93	Sigma
94	Becon
95	Microswitch
96	Wavetek
97	Electronic Concepts
98	Amelco
99	Mepco
100	RCA
101	Circuit Asm Corp
102	Monsanto
103	Ainsley
104	Keystone Carbon

TABLE 6.3 CODE LIST OF MANUFACTURERS

WARRANTY

ITHACO Inc. warrants each instrument to be free of defects in material and workmanship for a period of one year after shipment to the original purchaser; batteries are specifically excluded. Liability under this warranty is limited to repairing or adjusting any instrument returned to the factory for that purpose. The warranty of this instrument is void if the instrument has been modified other than in accordance with written instructions from ITHACO, or if defect or failure is judged by ITHACO to be caused by abnormal conditions of operation, storage or transportation.

This warranty is subject to verification by ITHACO, that a defect or failure exists, and to compliance by the original purchaser with the following instructions:

1. Before returning the instrument, notify ITHACO with full details of the problem; include model number and serial number of the instrument involved.

2. After receiving the above information, ITHACO will give you shipping instructions or service instructions. After receipt of shipping instructions, ship the instrument to ITHACO. Full liability for damage during shipment is borne by the purchaser. It is recommended that instruments shipped to us be fully insured and packed surrounded by at least 2 inches of shock-absorbing material.

ITHACO reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of ITHACO, and ITHACO neither assumes, nor authorizes any other person to assume for it, any liability in connection with the sales of ITHACO instruments.

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